Big Data Analytics Adoption in Pharmaceutical Supply Chain Management and its Impact on SCOR Processes: A Qualitative Study of the Australian Pharmaceutical Industry

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Abstract

Big Data Analytics (BDA) in supply chain management has recently drawn the attention of academics and practitioners. Big data refers to a massive amount of data from different sources, in different formats, generated at high speed through voluminous of transactions in business environments as well as within supply chain networks. Traditional statistical tools and techniques find it difficult to analyse this massive data. Modern applications, in the form of BDA, assist organisations to capture, store, and analyse data specifically in the field of supply chain. Although there is an increasing trend among academics to investigate the potentials of BDA in supply chain, there is a paucity of research on BDA in the pharmaceutical supply chain context.

In this research, the Australian pharmaceutical supply chain was selected as the case study. This industry is highly significant since the right medicine must reach the right patients, at the right time, in right quantity, in good condition, and at the right price to save lives. However, drug shortages remain a substantial problem for hospitals across Australia with implications on patient care, staff resourcing, and expenditure. Furthermore, a massive volume and variety of data is generated at fast speed from multiple sources (inter-organisational and intra-organisational data) in pharmaceutical supply chain, which needs to be captured and analysed to benefit operational decisions at every stage of supply chain processes. As the pharmaceutical industry lags behind other industries in using BDA, it raises the question of whether the adoption of BDA can improve transparency among pharmaceutical supply chain by enabling the partners to make informed decisions across their operational activities.

This study, therefore, aims to explore the determinants of BDA adoption in Australian pharmaceutical supply chain. It also examines the potential impacts of BDA adoption in various

processes using the Supply Chain Operations Reference model (SCOR model: plan, source, make, deliver, and return). The current study draws upon the Technology-Organisation-Environment (TOE) framework which is the most commonly used research framework that underpins the technology adoption studies.

An exploratory qualitative approach was adopted to analyse data collected through interviews. Twenty semi-structured interviews with top managers in 15 organisations comprising of five pharmaceutical manufacturers, five wholesalers/distributors, and five public hospital pharmacies were undertaken to investigate their views on BDA adoption. Therefore, the supply chain is considered as the unit of analysis in this study. The interviews were transcribed and imported into NVivo software for thematic and cross-case analysis. The thematic results identified several technological, organisational, and environmental factors that could motivate the Australian pharmaceutical supply chain entities to adopt BDA. The findings revealed that BDA would be more practical and helpful in the planning process, followed by delivery and return. However, no significant benefits of BDA were perceived for the sourcing and making processes of medicines.

This study contributes to the theory and practice. As business-related data gains momentum in business intelligence, this research explores the BDA potential in improving the supply chain processes of the pharmaceutical supply chain rather than focusing only on a single entity. Some earlier studies demonstrate BDA adoption in context of clinical healthcare; however, this study is the first of its kind that explores the determinants and benefits of BDA adoption in the Australian pharmaceutical supply chain comprising of hospital pharmacies, wholesalers/distributors, and manufacturers. Furthermore, this study also offers practical and managerial implications by providing top managers with a picture of the technological, organisational and environmental factors that may influence their BDA adoption decision. Moreover, this research enhances

managers' insight into the potentials of BDA at every stage of supply chain processes such as plan, source, make, deliver, and return and helps to improve decision-making in their supply chain operations. The findings will turn the rhetoric of data-driven decision into a reality where the managers may opt for analytics for improved decision-making in the supply chain processes.

Declaration

I, Maryam Ziaee, declare that the PhD thesis entitled “Big Data Analytics Adoption in Supply Chain Management and its Impact on SCOR Processes: A Qualitative Study of the Australian Pharmaceutical Industry” is no more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references, and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

9/3/2020

Signature Date

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List of Abbreviations

BDA	Big Data Analytics
BI	Business Intelligence
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DOI	Innovation Diffusion Theory
EDI	Electronic Data Interchange
GPS	Global Positioning System
HPV	Health Purchasing Victoria
IMS	Information Medical Statistics
IS	Information Systems
OECD	Organisation for Economic Co-operation and Development Countries
OTC	Over-the-counter
PBS	Pharmaceutical Benefits Scheme
RFID	Radio Frequency Identification
SAP	Systems, Applications, and Products
SCA	Supply Chain Analytics
SCC	Supply Chain Council
SCOR	Supply Chain Operations Reference model
SHPA	Society of Hospital Pharmacists of Australian
TGA	Therapeutic Goods Administration
TOE	Technology-Organisation-Environment Framework

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Chapter 1

Introduction

1.1 Introduction

This chapter introduces the thesis and justifies the selection of the research topic. Section 1.2 presents the background to this research. Section 1.3 discusses the research objectives and the research questions. Section 1.4 offers a brief discussion of the research methodology. Section 1.5 outlines the Ethics process of the research. Section 1.6 briefly introduces the research contribution. Section 1.7 outlines the structure of the whole dissertation.

1.2 Research Background

An efficient healthcare system in any country is underpinned by an efficient pharmaceutical supply chain as it ensures the provision and supply of medicines (Jaberidoost et al., 2015). In other words, pharmaceutical supply chain directly relates to the health and safety of patients (Mehralian, Zarenezhad, & Ghatari, 2015). The pharmaceutical supply chain refers to a network of organisations that are involved in manufacturing, distributing, and delivering medicines to patients (Settanni, Harrington, & Srai, 2017; Shah, 2004). One of the challenges of pharmaceutical supply chain is the issue of drug shortage which can pose serious threats to the health and life of patients (Saha & Jha, 2018). Thus, the right medicines must reach the right patients, at the right time, in good condition, and at the right price to save lives (Jaberidoost et al., 2015; Mehralian et al., 2015). This issue highlights the key role that the pharmaceutical supply chain plays, not only for the

healthcare sector and the government, but also to society at large (Mehralian, Moosivand, Emadi, & Asgharian, 2017).

However, the healthcare sector deals with numerous challenges in improving its efficiency (Dobrzykowski, Deilami, Hong, & Kim, 2014; Tormay, 2015) and seeks ways to decrease its costs while maintaining or even enhancing the quality of its care (Lee, Lee, & Schniederjans, 2011). Arguably, that supply chain expenses account for 38 per cent of healthcare costs—a very high figure compared to other industries such as retailers or electronics with five and two per cent respectively (Saha & Jha, 2018). One way to cut such costs is efficiency improvement in the supply chain (De Vries, 2011). The extant literature indicates that inadequate coordination among pharmaceutical supply chain actors (Privett & Gonsalvez, 2014; Saha & Jha, 2018) and the non-deployment of the right supply chain optimisation tools (Elmuti, Khoury, Omran, & Abou-Zaid, 2013) are the likely impediments in enhancing the efficiency of supply chains in this industry. Therefore, adoption and implementation of novel decision-making tools or techniques to optimise supply chains can result in improved productivity, reduced costs, and enhanced responsiveness (Saha & Jha, 2018). Such improvements can lead to further advantages such as improved healthcare, better management of resources, and patient satisfaction (Bhakoo, 2008).

An efficient supply chain relies on the adoption and implementation of novel supply chain tools to improve business processes. Innovation in supply chain can be defined as tools or techniques that create a seamless interaction among supply chain actors, improve business processes, and fulfil customers' needs with novel solutions (Lee et al., 2011; Lin, 2008). One type of supply chain innovation in the context of healthcare is technology-based innovation which is aimed at enhancing the overall delivery process, reducing delivery cycle time, improving the quality of products, and increasing organisations' performance (Lee et al., 2011). Supply chain innovations will also

benefit the patients through the efficient provision of medicines to hospitals (Andre et al., 2008; Shih, Rivers, & Hsu, 2009; Yoon, Lee, & Schniederjans, 2016).

Additionally, the healthcare sector provides one of the largest and fastest-growing datasets which includes clinical data, pharmaceutical data (Kambatla, Kollias, Kumar, & Grama, 2014), and supply chain data. The pharmaceutical healthcare supply chain encompasses multiple suppliers, manufacturers, wholesalers/distributors, retailers, and hospital/clinic pharmacies (Jetly, Rossetti, & Handfield, 2012). Business operations in these areas generate a huge volume of data from multiple sources that can be captured and analysed for the benefit of business decisions. Traditional statistical tools and techniques are incapable of managing and analysing the massive amounts of data, called 'big data', collected from various sources to reach meaningful decisions (Kaisler, Armour, Espinosa, & Money, 2013; Wang, Xu, Fujita, & Liu, 2016b). Efficient supply chain management relies on data-driven decisions. Therefore, modern techniques in the form of Big Data Analytics (BDA) can help organisations to store, manage, and analyse big data, specifically in the field of supply chain (Tiwari, Wee, & Daryanto, 2018). Despite the fact that pharmaceutical supply chain directly affects patients' wellbeing, it lags behind other industries in BDA implementation (Berger & Doban, 2014). Therefore, conducting research in this domain is worthwhile.

The Australian pharmaceutical supply chain is the context of this study for several reasons. The total expenditure of healthcare in Australia was $184.5 billion in 2017-18 which accounted for 10 per cent of GDP (Australian Institute of Health and Welfare, 2019a). This marks a huge increase of more than 50% in the past ten years (Australian Institute of Health and Welfare, 2018a). Healthcare expenditure is projected to double by 2054-55 (Australian Treasury, 2015). The growing healthcare expenditure is triggered by several factors including a greater focus on disease prevention, growing demand for a variety of medicines such as vitamins, herbal medicines, and

nutritional supplements, rising life expectancy, ageing population, increasing chronic diseases, and medical and technological developments (Richardson, 2018a). Furthermore, the pharmaceutical industry plays a pivotal role in the Australian economy. Australia has been known as the 15th largest medicine market across the world with a budget of the US $8.5 billion annually; however, this sector is beset by some challenges (Pharmaceuticals Industry Strategy Group, 2008). For instance, according to a survey conducted by The Society of Hospital Pharmacists of Australian (SHPA) in 2017, medicine shortages still remain a substantial problem for hospitals across Australia with significant implications for patient care, staff resourcing, and expenditure. Despite this significant challenge, Australia's share of research in the field of pharmaceutical supply chain remains minimal. As demonstrated in Figure 1.1, Europe and North America account for the highest proportion of research in pharmaceutical supply chain which is also reflected in the improvements in their healthcare system, pharmaceutical markets, and economies. These regions constitute around 70 per cent of the total value of the pharmaceutical market (Narayana, Pati, & Vrat, 2014). As indicated in Figure 1.1, the Australian pharmaceutical supply chain remains significantly under-researched, providing solid justification for this research which seeks to find ways to improve pharmaceutical supply chain practices by using BDA.

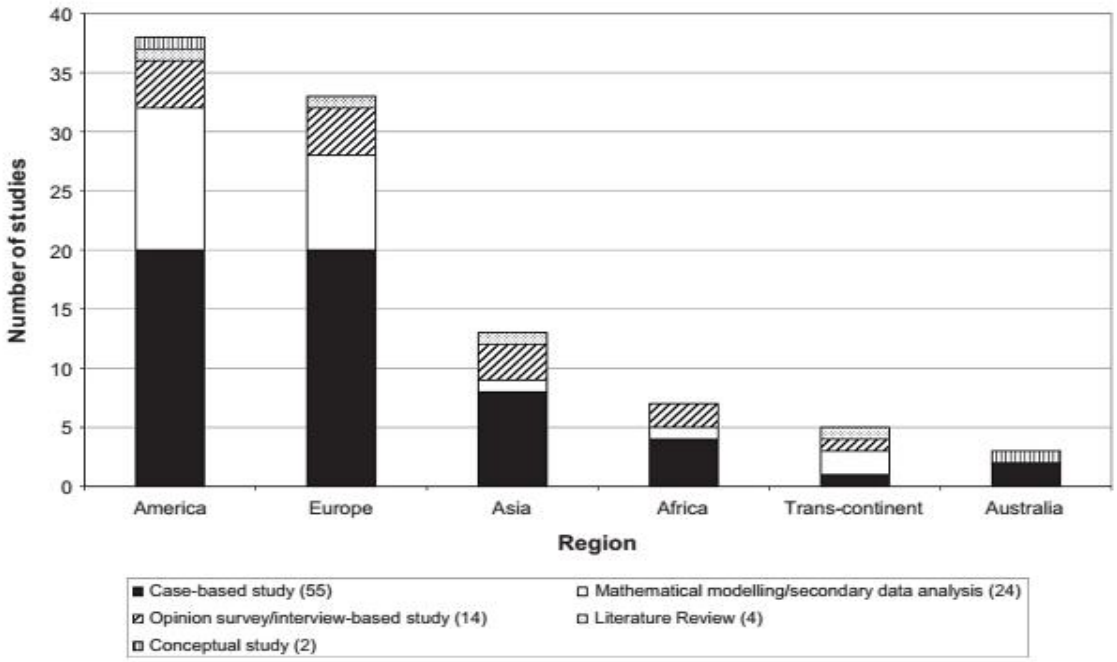

Figure 1. 1 Classification of studies based on geography and research methodologies

Source: Narayana et al. (2014)

To recap the significance of this research, it must be emphasised that the pharmaceutcal supply chain is a highly sensitive industry as it deals with the health and life of patients. The industry is beset by challenges such as rising supply chain costs, drug shortages, and lack of coordination among entitie. A huge amount of data is generated in the pharmaceutical industry, but it is not efficiently captured and leveraged to address the challenges of rising costs and lack of coordination. Therefore the adoption of new innovations can address some of the challenges. As mentioned earlier, research on the Australian pharmaceutical supply chain is relatively inadequate, especially with regards to the study of innovation adoption in pharmaceutical supply chain. In the context of Australia, healthcare expenditure is projected to grow significantly, and it is necessary to , research the adoption of novel technologies such as BDA in pharmaceutical supply chain, which can enable the industry to improve its operations (Tormay, 2015). Thus, the current study

aims to explore the determinants of BDA adoption and the benefits it offers in supply chain process management in the context of Australian pharmaceutical supply chain.

1.3 Research Objectives and Questions

As the pharmaceutical supply chain is directly related to the wellbeing of patients, research in this domain is worthwhile. However, the pharmaceutical industry lags behind other industries in BDA adoption research. Since BDA application is still in its infancy, organisations need to have a comprehensive understanding of the required resources and capabilities as well as the potential impediments they may encounter in the successful adoption and implementation of BDA. Therefore, **the first objective of this research is to investigate the determinants which can motivate or hinder organisations in BDA adoption.** In investigating the determinants of BDA adoption, it is imperative for the organisations to know the opportunities and values that BDA can offer in each of the supply chain processes. Since supply chain processes are comprised of planning, sourcing, making, delivery, and return (Supply Chain Council, 2010), this research is accordingly built upon the Supply Chain Operations Reference (SCOR) model which covers all of these five processes. The SCOR model offers a common framework for organisations to streamline activities among supply chain partners through connecting and unifying "business process, metrics, best practices and technology" (Supply Chain Council, 2010, p. 1). Each of the SCOR processes can be considered as both inter-organisational and intra-organisational practices (Li, Su, & Chen, 2011). The SCOR model encompasses all the necessary processes required to ensure the success of supply chain operations in achieving the ultimate goal of meeting customers' orders (Supply Chain Council, 2010). This comprehensive model covers all the supply chain activities ranging from placing orders, paying invoices, interacting with suppliers and customers to other

activities such as creating demand forecasts for markets and fulfilling customers' orders (Li et al., 2011). Thus, **the second underlying research objective is to explore how BDA capability affects decisions in each SCOR process.** It should be highlighted that this research is conducted in the context of the Australian pharmaceutical supply chain, encompassing three main supply chain actors including manufacturers, wholesalers/distributors, and public hospital pharmacies. The following two research questions address the objectives.

RQ_1: What are the determinants of BDA adoption in the Australian pharmaceutical supply chain?

RQ_2: How does BDA improve decision-making across supply chain processes (SCOR processes: plan, source, make, deliver, and return) in the Australian pharmaceutical supply chain?

1.4 Research Methodology

This research is qualitative and adopts an inductive paradigm utilising interviews across 15 different organisations. The nature of the research is an exploratory type (Yin, 2014) which seeks to capture a holistic view of the Australian pharmaceutical supply chain in order to investigate its readiness for the adoption of BDA. The use of a qualitative approach is warranted based on the nature of the research questions and the intention to develop propositions (Eisenhardt, 1989; Eisenhardt & Graebner, 2007), derived from a detailed analysis of interview responses. This approach is also an attempt to redress a balance in operations management disciplines which are mainly dominated by quantitative approaches, surveys, and statistical modeling which lend themselves better to theory testing rather than theory building (Halldórsson & Arlbjørn, 2005; Burgess et al., 2006; Golicic, Davis, & McCarthy, 2005; Reinecke, Arnold, & Palazzo, 2016; Stuart, McCutcheon, Hanfield, McLachlin, & Samson, 2002). Additionally, BDA adoption is a

new and complex phenomenon which requires in-depth and comprehensive understanding; this can be achieved through a qualitative approach that portrays a detailed picture of a dynamic and complex object of inquiry (Creswell, 1998).

Twenty interviews were conducted across 15 case organisations from among the key players in the Australian pharmaceutical supply chain. The selected organisations are equally distributed across the pharmaceutical supply chain comprising of five manufacturers, five wholesalers/distributors, and five public hospital pharmacies in order to present a balanced and holistic picture of their logistics activities in a real-world context. The sampling of these organisations follows Yin's (2014) recommendation to adopt a 'replication logic'. The concept of 'polar types' was also implemented (Miles & Huberman, 1994; Eisenhardt & Graebner, 2007) where one organisation, with unique or extreme characteristics, was selected in order to assess the validity of theories. The interviews were continued until the point of 'saturation' (Fusch & Ness, 2015; Guest, Bunce, & Johnson, 2006; Saunders, et al., 2018) was reached where no new information or insight emerged from informants.

Prior to the commencement of the data collection phase, two pilot interviews were undertaken in order to test the suitability of the interview questions concerning the content and study objectives (Yin, 2014). Apart from semi-structured interviews which were transcribed for data collection, a range of other sources such as additional interview notes, site observation, companies' documents, and government's reports were also used. The data analysis phase subscribed to an inductive method based on Yin's (2014) recommendation for a 'ground-up' approach where information was analysed and interpreted to build propositions. Using the N-Vivo software, emerging themes and concepts were identified and categorised through rigorous coding following Saldaña's (2013) guidelines. Initially, the data was broadly coded based on general concepts which were put into

categories in accordance with research questions. Subsequently, the second cycle of a more in-depth coding was conducted where data was reconfigured and sub-codes and sub-categories were created. The researcher employed a flexible coding strategy to be able to analyse and revisit the data to examine emerging themes in order to develop the propositions.

A thematic analysis was also conducted to identify and analyse themes and provide detailed interpretation (Boyatzis, 1998; Braun & Clarke, 2006). Through an inductive or 'bottom-up' approach, similar patterns and themes were identified (Braun & Clarke, 2006). Finally, a cross-case analysis was conducted to enhance the generalisability of research findings and conclusions. Emergent concepts and themes were first compared and contrasted among the cases within their own entities (manufacturers, wholesalers/distributors, and hospital pharmacies) and then against cases from the other entities. This phase proved highly conducive as data took shape and emergent theories were identified from data codes and categories to develop the propositions.

1.5 Research Significance

Although BDA adoption has been studied in different contexts (Agrawal, 2015; Chen, Preston, & Swink, 2015; Lai, Sun, & Ren, 2018; Verma & Bhattacharyya, 2017; Verma & Chaurasia, 2019), this study is the first of its kind to empirically investigate BDA adoption in the Australian pharmaceutical supply chain. Earlier studies have focused on the clinical trials of medicines (Phillips et. al., 2007; Tormay, 2015), but not their supply chain. BDA is an innovation for the Australian pharmaceutical supply chain entities and the innovation adoption at organisational level is determined by three contexts: technology, organisation, and environment (TOE). Therefore, this research builds upon the TOE framework which covers these three contexts. There is also a consensus among researchers that the TOE framework is a more comprehensive theory for the

study of innovation adoption (Awa, Ojiabo, & Orokor, 2017; Gangwar, Date, & Raoot, 2014; Hossain & Quaddus, 2011; Oliveira & Martins, 2011). Drawing upon the TOE framework, this research enriches the literature by proposing a framework that identifies technological, organisational, and environmental determinants which are significant to the BDA adoption intention in the Australian pharmaceutical supply chain.

A further theoretical significance lies in the fact that this thesis investigate the impact of BDA adoption on the decision-making in each SCOR process (i.e. plan, source, make, deliver, and return) in the pharmaceutical supply chain. Previously, studies either considered the SCOR model as a single construct or only focused on some of the SCOR processes (De Oliveira, McCormack, & Trkman, 2012; Trkman, McCormack, de Oliveira, & Ladeira, 2010; Zhu, Song, Hazen, Lee, & Cegielski, 2018). The investigation of each SCOR process also enables the Australian pharmaceutical entities to gain insights that BDA adoption can bring in each of these processes. These benefits include improved inventory management, efficient order fulfilment, human resource management, and quick responses to supply chain challenges. Analytics in the planning process supports pharmaceutical manufacturers and wholesalers in predicting and aggregating the demand and supply in their strategy in order to meet market requirements. Analytics in sourcing process will assist the entities to assess the suppliers' efficiency and select the preferred ones. Pharmaceutical manufacturers will be able to deliver their drugs in a cost-effective way using analytics in the delivery process. Analytics in the return process will help in the reverse flow of products from downstream to upstream using data-driven decisions. In addition, the role of government regulatory agencies in BDA adoption is also delineated that can motivate organisations to adopt BDA.

1.6 Ethics

During face-to-face interviews, human participants are exposed to some ethical issues. The very first measure the researcher took was to obtain the approval of the Ethics Research Committee of Victoria University (HRE18-074) to ensure the interview questions are in line with general ethical codes of conduct for research of this nature. Once the informants and entities were selected, they were provided with an overview of the research as well as the scope, purpose, and objectives of the interview. They were also informed of how the results would be used and published. Their role as interviewees was clarified in order to obtain their views. Consent forms, along with a list of questions, were provided to them prior to each interview. Furthermore, the privacy, confidentiality, and anonymity of informants and their corresponding organisations were guaranteed and maintained throughout the research.

1.7 Thesis Structure

Having delineated the research objective and established the justification for the study of big data analytics adoption in the Australian pharmaceutical supply chain, Chapter 2 presents an overview of the Australian healthcare system and the pharmaceutical industry along with a snapshot of its major supply chain actors. The chapter also outlines some of the pressing challenges encountered by pharmaceutical supply chains. Having established the context, chapter 2 also presents a detailed literature review as well as a description of the theoretical foundation of the thesis, Conceptual framework, and the research questions. Chapter 3 articulates the philosophical underpinnings and justification of the research methodology, with a detailed description of different research stages and how research data was collected and analysed. Chapter 4 presents the findings from the conducted analysis of the interviews. Chapter 5 presents a discussion of findings supported by

extant literature. This chapter also offers a series of propositions based on the discussion as well as a revised conceptual framework. Finally, Chapter 6 presents a summary of the thesis and highlights the theoretical and practical contributions as well as research limitations and suggestions for future studies.

1.8 Summary of Chapter

This chapter delineated the background for this research and provided justification for investigating BDA adoption in pharmaceutical supply chain in Australia. Pharmaceutical supply chain forms an integral part of Australian healthcare system as it is highly important to deliver the right medicine to the right patients at the right time and affordable costs. The Australian pharmaceutical supply chain is significantly under researched, especially with regards to the study of innovation adoption, which provides solid justification for this research that seeks to find ways to improve pharmaceutical supply chain processes through BDA. The current study aims to explore the determinants of BDA adoption and the benefits it offers in supply chain processes in the context of Australian pharmaceutical supply chain.

This chapter also outlined the research objectives and the associated research questions for the thesis. The chapter further explicated that the adopted theoretical lens for this research topic which is the TOE framework which can yield the best results. The research methodology of this study is qualitative which involves 15 organisations across pharmaceutical supply chain entities (manufacturers, wholesalers/distributors, and hospital pharmacies) with 20 interviews. The data is analysed through thematic, within and cross case analysis in order to offer a detailed picture of the current pharmaceutical supply chain processes in Australia and delineate the determinants of BDA

and how they can improve decision-making in each SCOR process. Consequently, the thesis makes novel theoretical and practical contribution. Figure 1.2 illustrates the structure of this thesis.

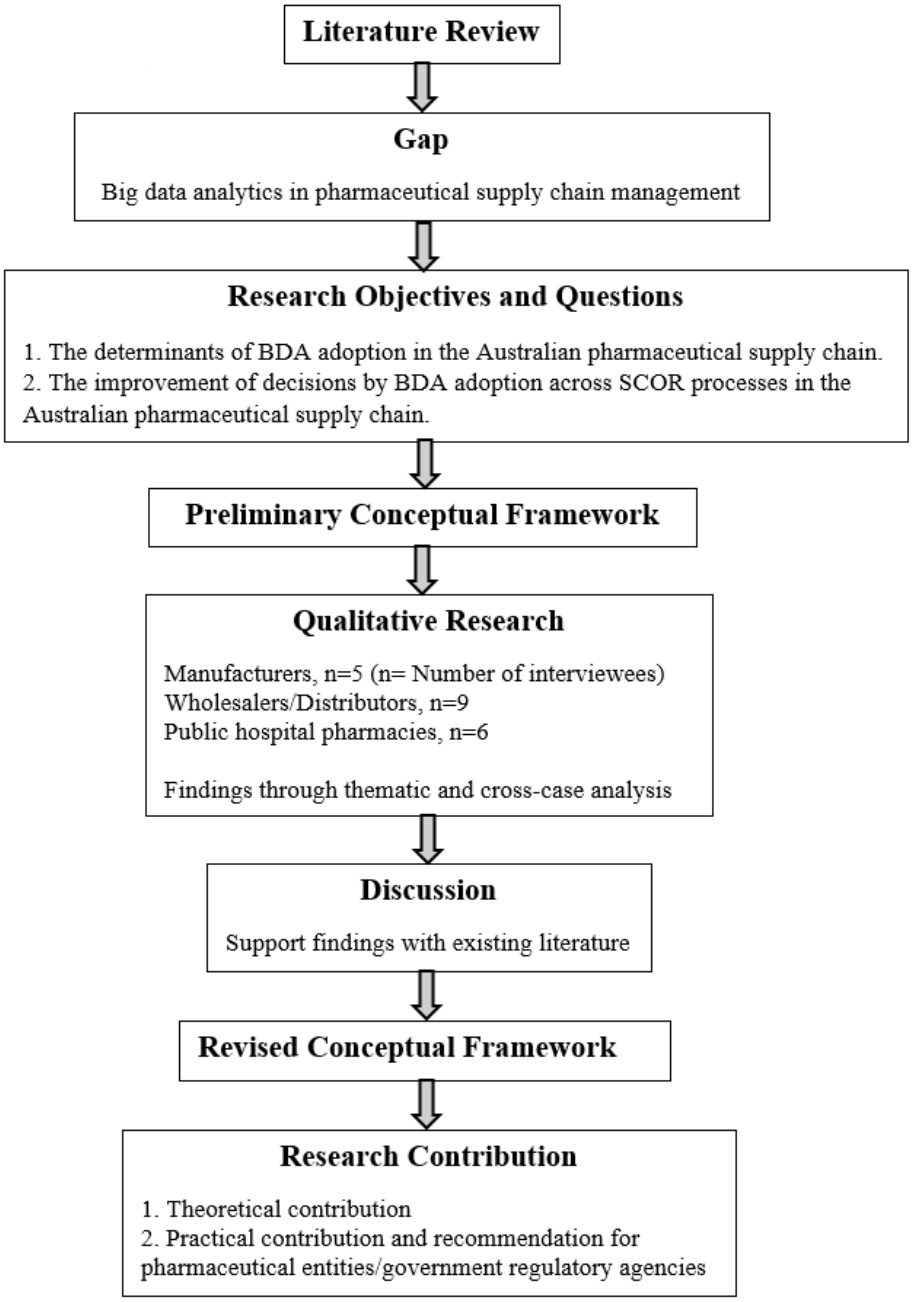

Figure 1.2 Thesis structure

Chapter 2

Literature Review

2.1 Introduction

This chapter presents a detailed literature review and establishes the context of the research. It also provides a detailed discussion of the conceptual framework that is adopted for the purpose of this study. Section 2.2 presents a detailed account of what constitutes big data and the evolution of analytics in the context of supply chains over the past 50 years. Section 2.3 provides a literature review of the application of big data analytics in the SCOR processes. Section 2.4 demonstrates how big data is deployed in the pharmaceutical healthcare sector, which is mainly in clinical trials. Section 2.5 discusses the implementation of big data in pharmaceutical supply chains and identifies the research gaps. Section 2.6 discusses the TOE framework which serves as the theoretical foundation of this study. Section 2.7 presents an overview of the Australian healthcare sector and its complexity. It also provides a summary of the challenges faced by pharmaceutical supply chains. Section 2.8 offers the initial conceptual framework of this research.

2.2 Big Data Analytics and Supply Chain Management

The amount of data generated through volumes of transactions in business environments (Chae & Olson, 2013) as well as within supply chain networks has increased exponentially (Stefanovic, 2014; Tiwari et al., 2018). It is estimated that the current volume of data that is generated on a daily basis equals 2.5 billion gigabytes and is expected to grow to zettabyte scale in the next few years (Ganeshan & Sanders, 2018). Data generation through transactions is very significant in

supply chain operations. For instance, approximately 600 items are sold per second by the giant online retailer, Amazon; Walmart also engages in over one million transactions per hour generating huge data (Ganeshan & Sanders, 2018). Figure 2.1 presents the amount of data that is projected to be generated by 2020.

Figure 2. 1 Global data volume predicted by International Data Corporation (IDC)

Source: Wang et al. (2016b)

This massive volume of data is known as 'big data' which cannot be ignored (Barton & Court, 2012); however, dealing with big data remains a challenge for businesses (Schoenherr & Speier-Pero, 2015; Tiwari et al., 2018). The first issue that arises is understanding what big data is and how it is defined in industries. The concept of 'big data', introduced in the late 1990s by Cox and Ellsworth, is generally defined as three Vs: Volume, Velocity, and Variety. Volume refers to the massive volumes of available data; Velocity refers to the speed or frequency of data generation or delivery, and Variety refers to data generation from various sources and formats (Russom, 2011). Later, scholars have added two more Vs namely: Value (the importance of achieving economic benefits from big data) and Veracity (the importance of the quality of data and also the level of trust in different data sources) (White, 2012). Technology has made different types of data

available including texts, images, audio, and videos and also different formats of data consisting of structured, semi-structured, and unstructured data. It is noted that more than 90% of big data is unstructured data and difficult to analyse (Gandomi & Haider, 2015; Ebenezer & Durga, 2015).

Regarding the features of big data, traditional statistical tools and techniques find it difficult to manage and analyse the fast-changing, massive amount of data from multiple sources to reach meaningful decisions (Kaisler et al., 2013; Wang et al., 2016b). Therefore, new techniques need to be applied to capture, organise, and analyse big data in order to leverage invaluable insights for the businesses (Wang et al., 2016b). Modern techniques in the form of big data analytics can help to store, manage, and analyse big data—specifically in the field of supply chain (Tiwari et al., 2018). In reality, BDA encompasses two technical areas which are combined. The first is the existence of massive available data and the second is the area of analytics which refers to different analytical tools such as statistics, predictive analytics, data mining, and artificial intelligence which are needed to analyse and interpret the data (Russom, 2011).

Contrary to conventional wisdom, big data is not, in and of itself, a novel phenomenon; however, the capability to leverage from the analysis and interpretation of big data is indeed new (Russom, 2011). BDA is actually a part of a continuum (Figure 2.2) which has been evolving and growing in complexity since 1950 in order to respond to organisations' need to process and analyse data as the nature of available data has also become more complex (Arunachalam, Kumar, & Kawalek, 2018).

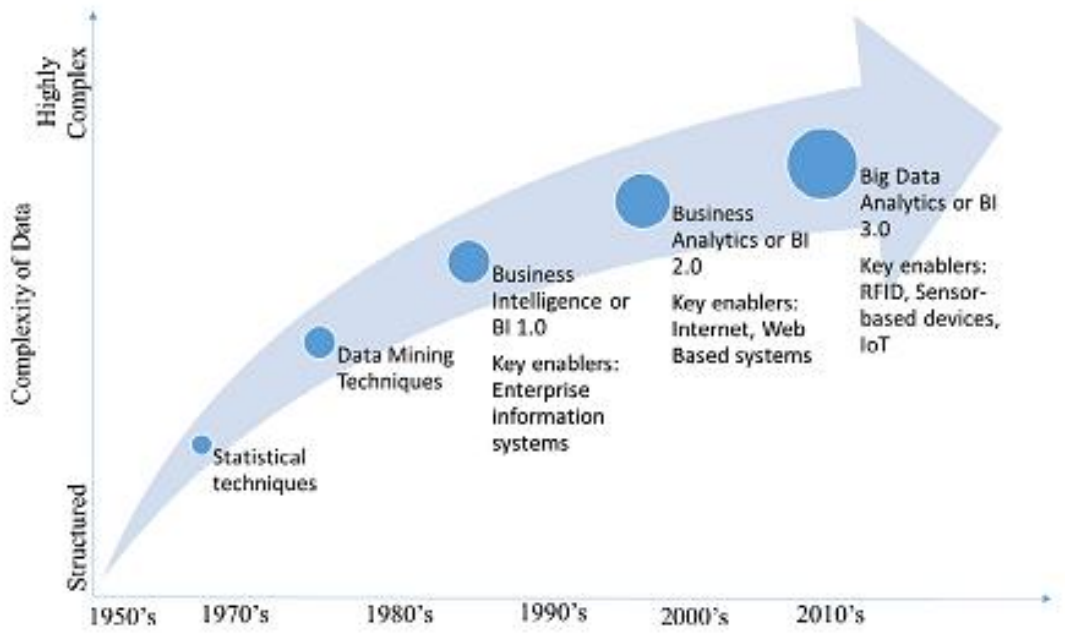

Figure 2. 2 The evolution of big data analytics

Source: Arunachalam et al. (2018)

As indicated in Figure 2.2, the developments in statistical techniques in the 1970s, combined with data mining techniques in the 1980s, gave rise to the concept of 'Business Intelligence' (BI) in the 1990s, known as first-generation BI 1.0 (Chen, Chiang, & Storey, 2012). Business intelligence refers to processes, techniques, and tools for analysing data to derive useful insights to improve strategic, tactical, and operational decision-making (Gudfinnsson, Strand, & Berndtsson, 2015). Business intelligence is composed of four main features including data warehouse, data sources, data mart, and query and reporting tools (Al-ma, 2013; Llave, 2017; Sahay & Ranjan, 2008), most important of which is a data warehouse, a combination of internal and external data stored in a database (Gudfinnsson et al., 2015). These features enable business intelligence to improve decision-making through the application of data mining, statistical techniques, and forecasting (Llave, 2017; Sahay & Ranjan, 2008).

The second generation of business intelligence, also known as BI 2.0, was enabled by the development of Internet technology in the early 2000s. An alternative term for business intelligence (BI 2.0) is 'Business Analytics' (BA) which is defined as the utilisation of data analytics techniques in different business areas (Chae, Yang, Olson, & Sheu, 2014). BA is currently been deemed as an integral part of organisations in supplying meaningful data/information to improve decision-making capabilities (Chen et al., 2012), and offers a substantial improvement over the first generation of business intelligence (Arunachalam et al., 2018).

In the early 2010s, the third generation of business intelligence, BI 3.0, gained more attraction which gave rise to what is currently known as 'big data analytics'. The distinguishing feature of BDA from traditional business intelligence practices is its capability to store a large array of structured and unstructured data from different sources in real-time, whereas traditional business intelligence tools can only analyse structured data, from homogenous sources at time intervals (Arunachalam et al., 2018; Vera-Baquero, Colomo Palacios, Stantchev, & Molloy, 2015). The main advantage of BDA tools is the technological capability to effectively utilise more recent databases such as NoSQL or Hadoop in order to aggregate and manage large volumes of data from heterogeneous sources and formats through sophisticated analytical techniques (Mortenson, Doherty, & Robinson, 2015).

There is a consensus among academic researchers and industry practitioners that there are numerous advantages that BDA offers (Tiwari et al., 2018; Zhong, Newman, Huang, & Lan, 2016). A survey, conducted by a data company called 'Transforming Data With Intelligence', indicates that 70% of their respondents deemed big data to be a favourable opportunity rather than a hindering challenge. The survey also identified that as big data databases were becoming more

financially viable, organisations recognised the significance of BDA and were willing to make investments in this area (Russom, 2011). Recently organisations have increasingly tried to develop and improve their BDA capabilities in an attempt to acquire a solid understanding of the potential benefits of BDA (Tiwari et al., 2018). A comprehensive and thorough analysis of big data can offer a range of valuable information regarding customer behaviour, operational costs, and the market (Russom, 2011). Therefore, organisations have better customer relationship management, explore potential markets for products or services, improve operational efficiency, enhance their business decisions resulting in increased profits (LaValle, Lesser, Shockley, Hopkins, & Kruschwitz, 2011)

Big data has a wide array of applications in the government sector, the service sector, as well as industries such as IT, manufacturing, finance, healthcare, and logistics and supply chain (Zhong et al., 2016). The countries leading the BDA applications are located in Europe, North America, and the Asia Pacific. The USA and Canada use big data in areas such as engineering and science, technologies for service sector such as emergency response, clean energy production, information technology, healthcare sector, and advanced manufacturing; Europe also employs big data in services as well as finance and logistics areas; and Asia Pacific countries such as China, Singapore, Japan, South Korea, and Australia are also investing in big data capabilities in different sectors for purposes such as predicting diseases before they occur in South Korea, leveraging forecasting techniques for natural disasters in Japan, and addressing challenges of infectious diseases and national security issues through analysis of large data sets in Singapore (Zhong et al., 2016).

Consultancy companies, such as McKinsey & Company, utilise BDA to provide business advice for their customers to improve their performance, such as the implementation of digital technologies in banks based on the analysis of their customer behaviour (Biesdorf, Court, &

Willmott, 2013). Retailers such as Amazon also use big data for anticipatory logistics where the company predicts what customers might order before they make a purchase (Zhong et al., 2016). A technology company, Intel, also relies on big data in order to expedite the development and launch of its new products (Zhong et al., 2016).

As SCA has been able to successfully deal with business challenges such as handling big data and business uncertainties, it has recently become a part of business agenda (LaValle et al., 2011; Manyika, 2011). For instance, some studies focused on the improvement of organisational performance through the use of BDA. Akter, Wamba, Gunasekaran, Dubey, and Childe (2016) investigate the relationship between BDA (comprising of three main scopes of management capability, technology capability, and talent capability) and an organisation's performance improvement with the moderating effect of analytics capability-business strategy alignment. Informed by a resourced-based view, Wamba et al. (2017) conducted survey-based research in China and developed a BDA capability model to investigate how BDA influences an organisation's performance. Chae, Yang, Olson, and Sheu (2014) examine the effect of data accuracy and analytics on organisations' performance with the moderating and mediating role of supply chain management initiatives as complementary resources.

2.3 Deployment of Big Data Analytics in the SCOR Model

Supply Chain Operations Reference (SCOR) model was developed and endorsed by the Supply Chain Council (SCC), an entity which strives to improve supply chain processes through its benchmarking and diagnostic tools and methodologies. Established in 1996, SCC is comprised of 69 organisations which represent a wide range of industries including retailers, manufacturers, and distributors. Apart from industries, the involvement of technology providers, researchers, and

government entities is vital for SCC to effect improvements in the SCOR model. This model offers a common framework for organisations to streamline activities among supply chain partners through connecting and unifying "business process, metrics, best practices and technology" (Supply Chain Council, 2010, p. 1).

The SCOR model divides supply chain activities into five major processes: plan, source, make, deliver, and return. Each of these processes can be considered as both inter-organisational and intra-organisational practices (Li et al., 2011). The SCOR model encompasses all the necessary processes required to ensure the success of supply chain operations in achieving the ultimate goal of meeting customers' orders (Supply Chain Council, 2010). The comprehensive model covers all the supply chain activities ranging from placing orders, paying invoices, interacting with suppliers and customers to other activities such as creating demand forecasts for markets and fulfilling customers' orders (Li et al., 2011). Figure 2.3 presents the schematic supply chain framework in the context of the SCOR model.

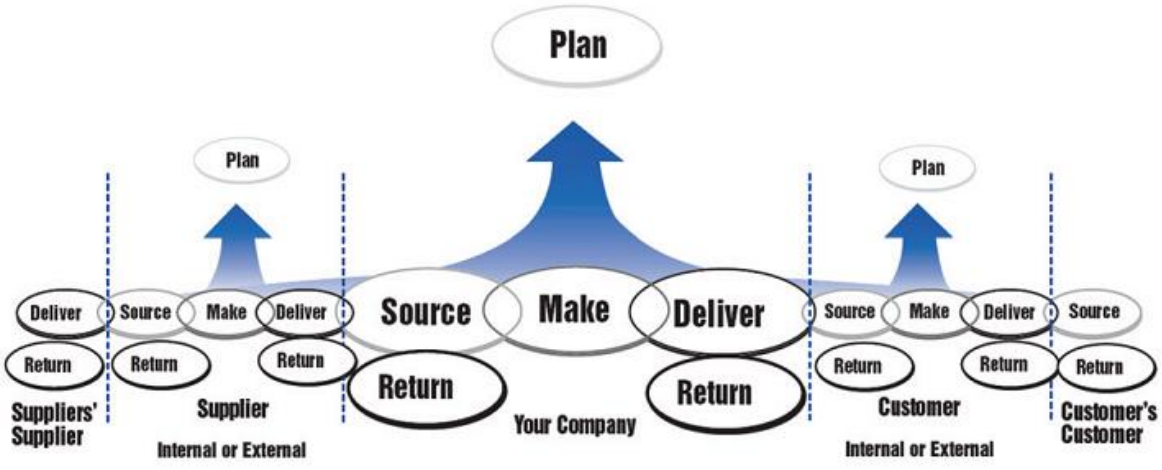

Figure 2. 3 Schematic supply chain framework in the context of the SCOR model

Source: Supply Chain Council (2010)

The SCOR processes and the activities are briefly explained. As stated by the Supply Chain Council (2010), the *planning process* refers to collecting information and resources, devising plans, anticipating demand and potential gaps, and identifying appropriate resources to remedy the gaps in order to enable the operation of supply chain. The *sourcing process* primarily involves ordering and receiving the required services and goods in the form of purchasing goods, receiving their deliveries, and storing them from suppliers. The *making process* refers to the activities involved in converting raw materials into a product or service. The *delivery process* is attributed to activities involved in the fulfilment and shipment of customers' orders, including validating the orders, dispatching and invoicing them. The *return process* refers to the "reverse flow of goods" including activities involved in the decision to return some products and the arrangement of dispatching the returned goods to the supplier.

The SCOR model can effectively lend themselves to the application of analytics tools to optimise processes. This is, in fact, not a recent trend as statistical methods have previously been used in order to balance supply and demand in supply chain (Souza, 2014). For instance, the utilisation of information systems (IS) in BA can be highly relevant and conducive to improving supply chain performance (Trkman et al., 2010). However, the development of big data in supply chain will offer new advantages while the implementation of big data in the supply chain is referred to as 'supply chain analytics' (Wang, Gunasekaran, Ngai, & Papadopoulos, 2016a). SCA is defined as the utilisation of analytical tools and data in order to improve the "flow of material along the supply chain" (Arunachalam et al., 2018, p. 418). SCA enables practitioners to collect data from various sources along the supply chain networks, interpret, and visualise data to derive insights and improve supply chain decisions (Arunachalam et al., 2018). Souza (2014) classified the analytical

tools of supply chain into three categories: descriptive, predictive, and prescriptive. Descriptive analytics derives information from big data to address the question of what is happening currently. This information is gathered from various resources such as Global Positioning Systems (GPSs), Radio Frequency Identification (RFID) chips, and data-visualisation tools to provide managers with real-time information about the location and quantities of goods in the supply chain. Predictive analytics derives demand forecasts at strategic, tactical, and operational levels from past data and responds to the question of what will be happening in the future. Prescriptive analytics derives decision suggestions built upon descriptive and predictive analytics models and mathematical optimisation models and answers the question of what should be happening.

The most prevalent data analytics category is prescriptive analytics on which both academics and industry practitioners have focused on producing a large body of research as well as analytics tools and software. This category is also quite significant in BDA and the supply chain domain. On the one hand, predictive analytics holds the middle ground and it must be noted as a major contributor to demand management and forecasting and mitigating procurement and sourcing risks (Nguyen, Li, Spiegler, Ieromonachou, & Lin, 2018; Ralha & Silva, 2012). On the other hand, descriptive analytics is the least studied category which is mainly used in warehouses, manufacturers, and transport and logistics (Helo & Hao, 2017; Wang, Wan, Zhang, Li, & Zhang, 2016c). Figure 2.4 demonstrates the distribution of SCA study types.

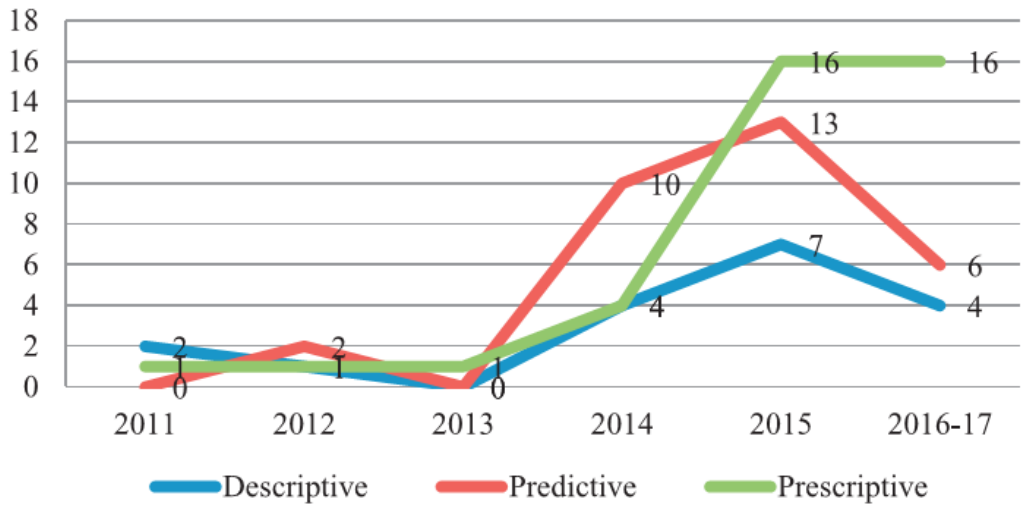

Figure 2. 4 Distribution of SCA study types

Source: Nguyen et al. (2018)

Analytics can be a powerful means to optimise the performance of supply chain practices. In general, supply chain involves a combination of organisations and processes which convert raw materials into products or services that are distributed to the ultimate customers. This process entails "physical, financial, and informational flows among different firms" (Souza, 2014, p. 595). The implementation of "supply chain analytics focuses on the use of information and analytical tools to make better decisions regarding material flows in the supply chain" (Souza, 2014, p. 595). Therefore, according to Souza (2014), utilising SCA can help industry practitioners to balance supply and demand more effectively. Since SCA comprises planning, sourcing, making, delivery, and return, these SCOR processes are applied as the framework for this study. Analysing the volumes of data generated from various resources at each stage of the supply chain process has a significant effect on business decisions. The following section will delineate how BDA can make improvements in each SCOR process.

2.3.1 BDA in Plan Process

Analytics in the planning process will help predict products and service requirements in the market (Biswas & Sen, 2016). An integral part of operations and supply chain management is demand forecasting which helps manufacturers to have an approximate estimate of demand for their products and thereby mitigate the potential risks of uncertainty at their planning stage (Lamba & Singh, 2017). This gives proof to the growing interest of managers in BDA to improve their demand forecasting and consequently their planning stage (Chase, 2013; Tiwari et al., 2018). New technologies have enabled organisations to capture and store an enormous amount of data emanating from their customers' buying behaviour or sales upon which their forecasts are based. However, the vast majority of this information has not been effectively used and analysed to yield benefits. The paucity of research about BDA in forecasting started after 2012 with the only little available research in this area (Lamba & Singh, 2017). One example of the application of BDA in demand forecast was a case study on retail enterprises in Switzerland where BDA analytics was revealed to improve the accuracy of forecast estimates (Hoftmann & Rutschmann, 2018). Arias and Bae (2016) investigated weather data and real-time traffic data in order to anticipate electric vehicle charging demands and help operators in their infrastructure planning. Kim and Shin (2016) used data from search engines to anticipate airline passenger demands which assisted the airport crew to better plan their operations and reduce their forecast errors. Therefore, the accurate demand forecast can be a powerful marketing and management tool to better manage inventory to meet customers' expectations (Tiwari et al., 2018).

2.3.2 BDA in Source Process

BDA can be an effective tool for the identification of new opportunities in the sourcing process. The application of BDA in the sourcing process will improve suppliers' evaluation and selection (Biswas & Sen, 2016). With the support of BDA, organisations can effectively evaluate and measure the performance of their suppliers in terms of sourcing (Wang et al., 2016b). The sourcing data can be aggregated and analysed to reveal insights about a supplier's performance criteria such as delivery punctuality, quality, or cost, thereby enabling organisations to make better decisions (Tiwari et al., 2018; Wang et al., 2016b). BDA can inform decisions regarding the suppliers who source raw materials at a lower price or with higher quality, and delivers them with improved efficiency and timeliness. Therefore, such various factors can be analysed via BDA in order to create an efficient model for selecting suppliers in different industries (Lamba & Singh, 2017). As an example, Jin and Ji (2013) have used analytics techniques such as fuzzy synthetic evaluation and analytic hierarchy process in order to propose a supplier selection model which reduces the risks of supplier selection and increases the reliability of selecting supply chain partners, leading to improved competitiveness. Lamba and Singh (2017) argue that annual sourcing costs can be reduced between two to five per cent through the implementation of BDA in this process. They also mentioned that traditionally organisations rely on enterprise resource planning systems; however, a considerable amount of working time (between 20 to 50 per cent) is spent on retrieving and searching for information in such systems which is a major drawback. In comparison, big data is capable of collecting and aggregating data far more quickly. BDA can also recognise existing patterns or trends in data which can lead to more reliable and accurate forecasts, rendering organisations more proactive rather than reactive in their sourcing process (Lamba & Singh, 2017).

2.3.3 BDA in Make Process

BDA in the making process can assist organisations in production planning and inventory planning (Biswas & Sen, 2016). Bi and Cochran (2014) argue that BDA can play a vital role in capturing, storing, and analysing data in manufacturing processes. To minimise waste and production delay, manufacturing organisations have often relied on methodologies such as six sigma or lean thinking (Auschitzky, Hammer, & Rajagopaul, 2014). Although, the manufacturing phase is accompanied by generation of large volumes of data, the implementation of BDA is this process is not fully fledged yet (Weng & Weng, 2013). There are several practical advantages that BDA brings to the manufacturing process (Lamba and Singh 2017). For example, the reduction of the discard rate as well as faster vaccine production at Merck, improving customer service and reducing costs at Xerox, and forecasting component failure in trucks at Volvo are all enabled by big data. BDA has also been used to optimise energy production through smart systems. The analysis of available real-time data has been used to develop a model for energy management systems in manufacturing environments which reduces both emissions and production costs (Katchasuwanmanee, Bateman, & Cheng, 2016). BDA can also be leveraged to improve inventory management by linking external suppliers and customers with production systems (Tiwari et al., 2018). Sharma and Garg (2016) have discussed the contribution of BDA to improve inventory systems and ordering decisions.

2.3.4 BDA in Deliver and Return Process

One of the seminal activities in operation and supply chain management is the inbound and outbound flow of materials in warehouses and management of activities related to delivery and return such as material handling and transport (Lamba & Singh, 2017). BDA in the delivery process will manage logistics so that the right products are dispatched to customers on time

(Biswas & Sen, 2016) and in the return process, BDA will decrease costs and improve inventory management and supply chain practices (Raman et al., 2018). In the delivery and return process, data is generated from a wide variety of sources such as smart devices, mobile apps, RFID, GPS, traffic data, weather conditions, EDI transactions, telematics, and so forth (Lamba & Singh, 2017). The benefits of BDA deployment in logistics and transport are numerous such as efficient storing and processing of large data sets generated from various sources, developing smart logistics projects informed by collected data, real-time monitoring of traffic, and developing anticipatory logistics, which can lead to improved customer satisfaction and increased revenues (Ayed, Halima, & Alimi, 2015). Logistics operations heavily rely on human resources which can incur high costs. In this area, BDA can help find optimum delivery routes, make efficient use of human resources to balance costs, and also focus on safety aspects and vehicle maintenance (Wang et al., 2016a). The application of BDA in logistics is still not fully mature, and it is mainly used for the above-mentioned purposes as well as optimal fleet refuelling, improving delivery times and vehicle maintenance as well as anticipating accidents based on drivers' performance (Frehe, Kleinschmidt, & Teuteberg, 2014; Hopkins & Hawking, 2018).

There is a direct relationship between organisations' competitiveness and productivity and the performance of their logistics activities in which the profits can grow considerably if logistics costs are reduced (Lamba & Singh, 2017). Practical examples of the application of BDA in delivery and process have also been recorded. A project in India was conducted on monitoring logistic fleet in real-time and gathering data based on several criteria such as speed, location, and fuel consumption in order to improve business decision-making. Hundreds of vehicles were involved in the project which sent data to the organisation's server every two seconds over wireless communication. The massive date was processed by Hadoop, an analytics software. This helped the organisation to

boost its productivity and reduce costs (Ayed et al., 2015). In the maritime shipping sector, BDA has been deployed to tackle the strategic and operational issues across such a wide network of carriers (Brouer, Karsten, & Pisinger, 2016). BDA can be used in sharing transport capacity in urban areas to improve the delivery efficiency of healthcare products (Mehmood & Graham, 2015). Third-party logistics services have also made investments in BDA that helped to integrate the operations in a more agile and seamless way for greater visibility (Tiwari et al., 2018).

2.4 Deployment of Big Data Analytics in Pharmaceutical and Healthcare Sector

The healthcare sector exhibits a large volume of data that have been generated over time in varying formats, types, and volumes that need to be managed and handled effectively. The body of rapidly produced data constitutes big data in the healthcare sector (Tiwari et al., 2018). Big data in the healthcare sector can be divided into two parts: internal data and external data. The internal data in a hospital encompasses clinical data, doctors' prescriptions, medical images like CT and MRI scan results, laboratory records, drugstore documents, and insurance files in digital formats (Ebenezer & Durga, 2015). The external data is generated across the supply chain (e.g. suppliers, manufacturers, distributors, and pharmacies/retailers) when the drugs and medicines move from the suppliers to the hospital pharmacies. Reportedly big data in the US healthcare sector was 150 Exabyte in 2011 and believed to reach Yottabyte (one million Exabyte) (Cottle et al., 2013). Due to the data growth rate in the healthcare sector, the existing analytical techniques cannot handle this volume of data. Therefore, a strategy to adopt a right analytics is needed to take the best advantage of big data in the healthcare sector.

BDA in the healthcare sector is beneficial in many ways. A study conducted by McKinsey & Company predicts that the business value from BDA in the US healthcare industry could be more than $300 billion per year (Manyika et al., 2011). For instance, BDA can help to detect frauds and errors (Srinivasan & Arunasalam, 2013); hospitals/clinics can make informed clinical decisions (Raghupathi & Raghupathi, 2014); doctors can apply the best treatments; and patients can acquire better healthcare services (Ebenezer & Durga, 2015). Research on BDA in the healthcare sector so far focuses mainly on BDA applications in clinical research (Ebenezer & Durga, 2015; Raghupathi & Raghupathi, 2014; Song & Ryu, 2015; Srinivasan & Arunasalam, 2013). These studies consider BDA as pivotal in reducing hospitals' costs, improving patients care quality, and supporting clinical decisions. They also discuss barriers and challenges to the application of BDA in hospitals such as managerial issues, shortage of qualified staff, and the lack of high-quality data.

Some researchers have investigated the influence of BDA in the healthcare sector in greater depth; for instance, Chawla and Davis (2013) have proposed a framework which captures and stores data from patients based on similar symptoms, demographics, occupations, and family history. The framework then aggregates the data and offers a risk profile for each individual patient. This profile can serve as a proactive solution as it assists physicians in assessing possible risks for their patients. Barrett, Humblet, Hiatt, and Adler (2013) argue that big data can be used to identify risk factors and behaviours that might create health risks in a specific population and offer solutions to promote a healthier option and mitigate risk. This can serve as a preventive model to improve general health and reduce healthcare costs. Big data is also used to reduce cancer and asthma attacks based on the gleaned data from inhalers (Nambiar, Bhardwaj, Sethi, & Vargheese, 2013). As evidenced above, BDA plays a significant role in the clinical side of the healthcare sector by reducing costs, improving patients' health, and supporting clinical decisions.

BDA in the pharmaceutical sector can contribute to developing new medicines in a timely and cost-effective manner (Schultz, 2013). During different phases of the drug development and approval process — which could take approximately two to three years—a torrent of data is generated through patients' feedback or the tracking of diseases over time. This data provides a valuable source for pharmaceutical manufacturers, patients, doctors, and healthcare decision-makers to improve the care quality and medicines during the life cycle of any given product or medicine (Wasser, Haynes, Barron, & Cziraky, 2015). The benefit of BDA in integrating various data points in the pharmaceutical industry is identification and efficacy assessment of new drugs, improvement in clinical trials and treatment methods, enhanced patient satisfaction, development of new therapies, and disease prevention (Tormay, 2015).

For instance, Pfitzer used The Health Improvement Network database to study the effects of switching cardiovascular medicine on more than 11,000 patients (Phillips, et. al., 2007). In a similar vein, Sanofi, a French pharmaceutical company, conducted meta-analysis research on studies obtained from databases and random clinical trials from over 80,000 patients in several countries to assess the risk of cancer for patients with diabetes who use the company's insulin (Tormay, 2015). Another example is the collaboration between AstraZeneca Pharmaceuticals and HealthCore, a healthcare database company who conducts observational studies as well as comparative effectiveness research to assess the efficacy of different medicines for chronic diseases in order to improve patients' health and lower healthcare costs (Tormay, 2015).

Thus, BDA applications remain confined to a select few cases for the purpose of clinical trial. The studies above indicate the growing need to employ BDA in today's modern healthcare system. While these studies are mostly narrowed down to intra-organisation operations, the optimal use of data-centric decision-making among partners in a pharmaceutical supply chain context is

underexplored. The current study addresses the gap in the pharmaceutical supply chain by investigating the operations across the supply chain entities rather than within a single organisation. Thus, this study looks at incorporating hospital pharmacies, wholesalers, and manufacturers that deliver drugs in full and on time (DIFOT).

2.5 The Gap—Big Data Analytics in Pharmaceutical Supply Chain

2.5.1 Gap 1—Big Data Analytics Adoption Determinants in Pharmaceutical Supply Chain

The potential application of BDA has not been fully exploited in supply chain for actionable insights. This shortcoming is partly due to the inability of organisations to process huge amount of data or the use of inaccurate data that can incur unnecessary extra costs and yield no useful results (Tiwari et al., 2018). Despite the fact that some organisations utilise BDA to gain competitive edge and boost their business intelligence, many have yet to understand what constitutes BDA and how to employ it—a fact which highlights the importance of exploring BDA adoption (Kwon et al., 2014). Therefore, for those organisations who intend to adopt BDA in their supply chain processes, it is imperative to explore the determinants which motivate or hinder BDA adoption. The literature shows a dearth of empirical research on BDA adoption and its determinants. Therefore, it is significant to explore the factors which exert influence on the decision to adopt BDA in supply chain operations (Lai et al., 2018).

There are already a few studies conducted to explore the determinants of BDA adoption intention. Underpinned by the TOE framework, authors of these studies intend to identify BDA adoption

determinants, a summary of which is presented in Table 2.1. One such study was conducted by Verma and Chaurasia (2019) who devised a survey-based questionnaire to analyse BDA adoption factors in a range of industries in India. The group analysis of the adopting organisations showed several determinants such as competitive pressure, relative advantage, management support, technological readiness, compatibility, organisational data environment, and complexity; and non-adopting organisation found competitive pressure, relative advantage, and complexity as important determinants. Drawing on the TOE framework and Innovation Diffusion Theory (DOI), Lai et al. (2018) devised survey-based research based on 210 organisations from several industries in China. The results indicated that top management support and relative advantage were seminal determinants, as well as some environmental factors such as government policies and competitors' adoption that played a moderating role in BDA adoption. Verma and Bhattacharyya (2017), based on interviews of 22 organisations in India, identified the following inhibitors: the lack of understanding of strategic value of BDA, and their unpreparedness to adopt due to technological, environmental, and organisational issues. Using a survey of 106 organisations in China and India, Agrawal (2015) found regulatory environment as the most significant determinant of BDA adoption. Chen et al. (2015) surveyed 161 organisations in America and suggested that relative advantage and technology capability exerted a direct impact on BDA adoption, while organisational and environmental determinants had an indirect influence. Additionally, Ramanathan, Philpott, Duan, and Cao (2017) conducted a study involving nine case-studies to investigate the relationship between the environmental factors and BA adoption determinants and its impact on business performance.

The earlier investigation of BDA adoption studies listed in Table 2.1 show the research at the organisational level. The data collection, analysis, and the findings of these studies were limited

to the organisations being the unit of analysis. Most of them have adopted the survey-based perceptual studies. No such extant studies, to the best of the researcher's knowledge, are available at the level of supply chain being the unit of analysis. This study, therefore, addresses the gap by adopting a qualitative approach to explore BDA adoption intention in the pharmaceutical supply chain that comprises of hospital pharmacies, wholesalers/distributors, and manufacturers. As the pharmaceutical supply chain is directly related to the wellbeing of patients at hospitals, research in this domain is worthwhile to explore the partner organisations' intention to exploit the potential of BDA in support of patient care. The pharmaceutical industry lags behind other industries in BDA adoption research. Therefore, by building on the TOE framework, this study proposes a conceptual framework to explore the determinants of BDA adoption in the Australian pharmaceutical supply chain. While the literature shows the use of surveys being the dominant approach, this study employs a qualitative method using face-to-face interviews in order to gain a comprehensive understanding of BDA adoption intention. The review of the extant literature also indicates that previous studies neither focused on a specific industry nor considered the major actors in its supply chain in order to gain an in-depth view of the supply chain. The current study conducts research on the main actors of the Australian pharmaceutical supply chain including manufacturers, wholesalers/distributors, and public hospital pharmacies. In doing so, this research addresses the gap by focusing on one specific industry and analysing the major actors of its supply chain. Besides, BDA adoption has been studied in the clinical trials of pharmaceutical healthcare sector, but not the supply chain of pharmaceutical products that this study seeks to cover.

Table 2. 1 The summary of the extant literature on BDA adoption and its impact on supply chain processes

Research	Research Objective	Country	Context	Methodology & Theory
Verma & Chaurasia (2019)	The Investigation of BDA adoption determinants	India	Different industries	Survey-based TOE framework
Lai et al. (2018)	The Investigation of BDA adoption determinants	China	Different industries	Survey-based TOE framework & DOI theory
Verma & Bhattacharyya (2017)	The Investigation of BDA adoption determinants	India	Different industries	Semi-structured interviews TOE framework
Chen et al. (2015)	The Investigation of BDA adoption determinants	The US-based organisations	Different industries	Survey-based TOE framework & dynamic capability theory
Agrawal (2015)	The Investigation of BDA adoption determinants	China and India	Different industries	Survey-based TOE framework
Ramanathan et al. (2017)	The Investigation of BA adoption determinants	The UK	Retail sector	Case studies TOE framework
Zhu et al. (2018)	The effect of SCA on operational supply chain transparency	The USA, Asia, Europe	Different industries	Survey-based Information processing theory
De Oliveira et al. (2012)	The effect of BA on supply chain performance	the USA, Canada, Brazil, Europe, and China	Different industries	Survey-based
Trkman et al. (2010)	The effect of BA on supply chain performance	the USA, Canada, Brazil, Europe, and China	Different industries	Survey-based Information processing theory

2.5.2 Gap 2—Effect of Big Data Analytics across SCOR Processes in Pharmaceutical Supply Chain

Having discussed the determinants of BDA adoption in organisations across different sectors, this section presents the extant literature which empirically investigates the benefits of BDA in both internal and external organisational practices. This is summarised in Table 2.1. Trkman et al. (2010) conducted a survey-based research with participants chosen from different industries (e.g. manufacturing, food, logistics and communication service, home utilities, and automotive) in different countries. They describe the impact of the use of BA in four processes of the SCOR model (plan, source, make, and deliver) on supply chain performance with the moderating effects of IS and business processes orientation. The results reveal that BDA does not play a major role in the delivery process yet—possibly due to the technical immaturity of the organisations in analytics capability.

In a similar vein, De Oliveira, McCormack and Trkman (2012) investigate the effect of BA on supply chain performance in four areas of the SCOR processes (plan, source, make, and deliver). They argue that organisations may not be able to make simultaneous efforts in all areas of supply chain. Organisations at different maturity levels need to focus on different areas of SCOR processes. Survey results show that an investment in analytics is likely to improve the performance of the organisations at any maturity level. Also, the impact of BA on supply chain performance does not only depend on the supply chain process maturity but also on other variables, such as the type of supply chain and the industry in question. Informed by organisational information processing view theory, Zhu et al. (2018) conducted survey-based research to investigate the role of analytics in the transparency of supply chain operation in four SCOR processes: plan, source,

make, and delivery. The research reveals that analytics in planning process indirectly contributes to supply chain transparency whereas the analytics capability in the source, make, and delivery processes directly contribute to supply chain transparency.

As demonstrated in the literature review, cited above in Table 2.1, the 'return process' of the SCOR model is not well-researched in SCA, which this thesis seeks to cover. Moreover, as demonstrated, the existing literature focuses on SCA in a survey-based research paradigm in a variety of different industries broadly, whereas this thesis only concentrates on one industry—namely, the Australian pharmaceutical supply chain, from a qualitative approach, where interviews allow the researcher to drill down further into its object of inquiry. This research, therefore, investigates the role of BDA in all five SCOR processes.

2.6 The Technology-Organisation-Environment Framework

This research has used technology, organisation and environment (TOE) framework as a foundation. Since the BDA adoption will be essentially a new initiative for the partner organisations of the pharmaceutical supply chain, the acceptance of such new tools and techniques will be an innovation for them. Innovation is defined as the adoption, development, or deployment of novel processes, structures, services, systems, or strategies, in an organisation whether they are created internally or acquired externally (Damanpour, 1991). Innovation adoption can occur both at an individual level and an organisational level (Lai, Sun, & Ren, 2018). Innovation adoption, such as Information technology (IT), has been researched extensively from both theoretical and empirical perspectives where different theories were investigated (Oliveira & Martins, 2011; Verma, & Bhattacharyya, 2017). On an individual level, the TOE is utilised to investigate the IT innovation adoption in the form of the technology acceptance model (Davis, 1989), motivational

model (Davis, Bagozzi, & Warshaw, 1992), theory of planned behaviour (Ajzen, 1991), and technology readiness index (Parasuraman, 2000). From an organisational perspective, several authors (Chong, Lin, Ooi, & Raman, 2009; Oliveira & Martins, 2011; Verma, & Bhattacharyya, 2017) demonstrate that organisational innovation adoption mainly adheres to DOI theory (Rogers, 2003) and/or the TOE framework (Tornatzky & Fleischer, 1990).

Despite the commonalities between DOI theory and the TOE framework, the current research is solely guided by the TOE framework. The justification for the selection of the TOE framework is based on the fact that this framework offers the environment context that enables a more detailed understanding of decision-making processes (Lai et al., 2018). There is a consensus among researchers that the TOE framework is a more comprehensive theory for the study of innovation adoption (Awa et al., 2017; Gangwar et al., 2014; Hossain & Quaddus, 2011; Oliveira & Martins, 2011).

Thus, the TOE framework pertains to organisational level innovation adoption and argues that innovation adoption in an organisation is determined by three contexts: technology, organisation, and environment. Each of them influences the adoption decision at an organisational level (Sutanonpaiboon & Pearson, 2006; Verma, & Bhattacharyya, 2017). Although, there are other numerous factors which might impact an organisation's adoption decision, the TOE framework is all-encompassing and all other factors fall in one of its three contexts. Hence, it is suitable for the investigation of BDA adoption decision (Verma & Chaurasia, 2019). Each of the three TOE framework context is expanded below.

2.6.1 Technology Context

The technology context refers to any technology and related innovation that pertain to an organisation's activities, whether these technologies are deployed or are yet to be deployed in the organisation (Verma & Bhattacharyya, 2017). The technologies that are already deployed can influence others as they determine the limits and the pace of technology adoption in an organisation. Those are yet to be deployed in the organisations can also have an influence as they set the limits of technological adoption and reveal their potential (Baker, 2012). The available technologies that are not adopted by organisations can affect three types of change: incremental, synthetic, and discontinuous. Incremental change refers to technologies that are newer versions of existing ones while processing further capabilities. These technologies are the safest and least disruptive. The synthetic changes are attributed to technologies which are merged with the existing ones in new ways and often present some modest changes. The discontinuous changes are technologies that are fundamentally different and present dramatic changes (Baker, 2012). Technology context includes numerous factors or determinants which can inhibit or encourage technology adoption. Sun, Cegielski, Jia, and Hall (2018) have analysed 62 research papers published on business intelligence and analytics between 2009 to 2015 in order to identify the most prevalent determinants. They identified 26 factors which they incorporated into the TOE framework, some of which are presented below.

- Relative advantage: The characteristics of a new technology surpass its precedents in the advantages it provides in terms of productivity, customer service, business solution, etc.
- Cost of adoption: It refers to the costs and investments required for technology adoption in terms of IT infrastructure in an organisation and other affiliated costs.

- Technology complexity: It relates to the difficulty of acquiring the knowledge and training the staff to use and understand new technology.
- Technology compatibility: The new technology is consistent and compatible with the existing IT infrastructure and systems of an organisation so that it can be easily integrated.
- Observability: The benefits of a new technology are easily observable or perceptible if a potential adopter observes an organisation which has already adopted the technology.
- Trialability: The new technology can be adopted without full commitment to use its whole scale or it can be easily trialled.

2.6.2 Organisation Context

Organisational context refers to the internal capabilities and resources of an organisation which can play a role in innovation adoption intention (Tornatzky & Fleischer, 1990). Some determining factors in organisational context can be tangible and others intangible (Hwang, Huang, & Wu, 2016; Pudjianto & Hangjung, 2009). Some of the most seminal determinants in the organisational context, according to Sun et al. (2018), include the following:

- Human resources: An organisation's human resources, such as skilled staff, are sufficient for the adoption of a new technology.
- Technology resources: An organisation's technological resources, such as hardware and software systems, are sufficient for the adoption of a new technology.
- Top management support: It refers to the top management support in the form of providing resources, investments and initiatives to adopt a new technology.
- Decision-making culture: It refers to the culture of 'evidence-based decision-making' in an organisation at the managerial level.

- Business strategy orientation: It refers to an organisation's strategy which is oriented towards the adoption of technologies such as BDA to inform their strategic decisions.
- Business resources: It refers to the available resources such as data-sharing culture or forward-looking policies within a business that encourage technology adoption.
- Change efficiency: It refers to the capability of an organisation to manage change effected by technology adoption.
- Information System (IS) strategy orientation: It refers to the degree to which the IS strategy of a business is supportive of technology adoption such as BDA.
- Firm size: It refers to the revenue and size of an organisation which intends to adopt a new technology.
- Appropriateness: It refers to the time when an organisation decides to adopt a new technology. The adoption time should be appropriate for organisations.

2.6.3 Environment Context

The environmental context refers to the external factors which influence innovation adoption decision (Verma & Bhattacharyya, 2017). Some of the most seminal determinants in the environmental context, according to Sun et al. (2018) include the following:

- Security, privacy, and ethical concerns in data collection phase: It refers to legal ramifications of private information/data collected from customers.
- Trading partner pressure: This factors means that an organisation is pressured to copy or follow a partner organisation's strategy in adopting new technologies in order to maintain balance with their partners.

- Government policies and regulations: Regulatory environment (government) is supportive of technology adoption in terms of providing legal protection and encouraging adoption.
- Institutional based trust: It refers to the degree of faith and belief inside an organisation that it can adopt new technologies smoothly and safely.
- Competitive pressure: It refers to pressure from competitors which can be overcome through new technology adoption.
- Market turbulence: It refers to changes in customers' behaviour and expectations related to their preferences, products and demands.

The existing literature confirms that the TOE framework has been widely used as a conceptual framework to analyse the determining factors of innovation adoption. Examples of such studies in innovation adoption based on the TOE framework include cloud computing (Ahmad & Waheed, 2015; Alshamaila, Papagiannidis, & Li, 2013; Gangwar, Date, & Ramaswamy, 2015; Hsu, Ray, & Li-Hsieh, 2014; Lian, Yen, & Wang, 2014; Low, Chen, & Wu, 2011), e-commerce (Ghobakhloo, Arias-Aranda, & Benitez-Amado, 2011; Rahayu & Day, 2015), enterprise application (Ramdani, Chevers, & Williams, 2013), radio frequency identification (Bhattacharya & Wamba, 2018; Fosso Wamba, Gunasekaran, Bhattacharya, & Dubey, 2016; Wang, Wang, & Yang, 2010), information and communications technology (Pudjianto & Zo, 2009), e-business (Zhu, Kraemer, & Xu, 2006), as well as big data analytics (Agrawal, 2015; Chen et al., 2015; Lai et al., 2018; Verma & Bhattacharyya, 2017; Verma & Chaurasia, 2019). As demonstrated, the TOE framework is a highly versatile theory which has been employed in different countries and across various industries such as healthcare sector (Cao, Jones, & Sheng, 2014; Lian et al., 2014), manufacturing organisations (Aboelmaged, 2014; Zhu et al., 2006), wholesaler/retailer sector and

financial services (Zhu et al., 2006), and government (Pudjianto, Zo, Ciganek, & Rho, 2011). Table 2.2 summarises some previous studies used the TOE framework for their research.

Table 2.2 Examples of studies in different innovation adoption context based on the TOE framework

Innovation adoption	References
Big Data Analytics	Agrawal (2015); Chen et al. (2015); Lai et al. (2018); Verma & Bhattacharyya (2017); Verma & Chaurasia, 2019.
Cloud Computing	Ahmad & Waheed, 2015); Alshamaila, Papagiannidis, & Li, 2013); Gangwar, Date, & Ramaswamy, 2015); Hsu, Ray, & Li-Hsieh, 2014); Lian, Yen, & Wang, 2014); Low, Chen, & Wu, 2011).
E-commerce	Ghobakhloo, Arias-Aranda, & Benitez-Amado (2011); Rahayu & Day (2015).
Enterprise Application	Ramdani, Chevers, & Williams (2013).
Radio Frequency Identification	Bhattacharya & Wamba (2018); Fosso Wamba, Gunasekaran, Bhattacharya, & Dubey (2016); Wang, Wang, & Yang (2010).
Information and Communications Technology	Pudjianto & Zo (2009).
E-business	Zhu, Kraemer, & Xu (2006).

In the application of the TOE framework, the three contexts (technology, organisation, and environment) remain the same; however, factors under each context can differ from one another depending on the type of technology, the host industry, or the country in which the technology is being adopted (Baker, 2012). In other words, the contexts remain constant, but the underlying

factors vary (Baker, 2012; Lai et al., 2018). Due to the varying factors in each TOE context, researchers have called for broader application of the TOE framework in different industry contexts (Awa et al., 2017; Gangwar et al., 2014). In a similar vein, authors (Dubey, Gunasekaran, Childe, Wamba, & Papadopoulos, 2016; Kwon, Lee, & Shin, 2014) recommend more research to further explore the determinants of BDA adoption in organisations. This research, therefore, is the first of its kind to utilise the TOE framework to investigate the BDA adoption determinants in the Australian pharmaceutical supply chain. It should be noted that as technology continues to grow and transform organisations and business models, the TOE framework will remain a relevant, potent and comprehensive model to study technology adoption in different contexts. Therefore, empirical research informed by this framework can continue to offer useful information in both academia and industry (Baker, 2012).

2.7 Overview of the Australian Pharmaceutical Healthcare Industry – The Context

This section of the research presents a snapshot of the Australian healthcare system, its standing in OECD (Organisation for Economic Co-operation and Development) countries and a description of the main supply chain entities (manufacturers, wholesalers/distributors, and public hospitals) in order to establish the research context and develop a conceptual framework.

Prior to exploring the Australian healthcare system, it is conducive to have a snapshot of the healthcare systems in some of the OECD's countries which have a comparable economic market to that of Australia. To this end, the United Kingdom, Canada, and The United States have been selected.

The United Kingdom's National Health Service (NHS), which was founded in 1948, boasts of a relatively well-coordinated and centralised system, with a centralised funding model which emphasises "equitable [and] free access" (Peckham, 2014) that provides many services free of charge at the point of use (Cylus, Richardson, Findley, Longley, O'Neill, & Steel, 2015).

The UK's healthcare system performs well proportionate to the country's healthcare spending, with an average life expectancy of 81.3 (OECD, 2019). The country's healthcare system is a tax-funded model (European Commission, 2019) where, according to UK's Office for National Statistics (ONS), the country allocated £214.4 billion to healthcare expenditure in 2018 which equated to £3,227 per person (ONS, 2020). The UK's health budget accounts for about 10% of the country's total GDP and it is estimated to rise to about 11.4% of its GDP by 2030 (OECD, 2020). Of all the country's healthcare expenditure, about four fifth of the expenditure (78%) which equates to £166.7 billion was financed by the government through general taxation in 2018 (ONS, 2020). In this respect, the UK is well above other OECD countries in providing government funding. UK's spending on pharmaceuticals constituted 12.3% of its total health spending in 2018 (OECD 2020). UK's expenditure on medicine has increased significantly from £13 billion in 20111 to £17.4 billion in 2017, which equates to an annual increase of 5% (Ewbank, Omojomolo, Sullivan, & McKenna, 2018). One of the reasons for this spike in expenditure is drug shortages that occur in the supply of some generic medicine (Ewbank et al, 2018). The UK's government is also utilising new technologies and digital transformation in its health system. However, this is mainly in the area of clinical research and deployment of apps to access health services or general practitioners (European Commission, 2019), but not in the supply chain of pharmaceutical products.

Canada's healthcare system bears very close resemblance to that of Australia as Canada is also a confederate where different provinces and territories are involved in the administration and service delivery, but the overall system is regulated and standardised through federal regulations. Canada's healthcare system, known as Medicare, provides equitable and accessible service to many Canadians, free of charge (Martin, Miller, Quesnel-Vallée, Caron, Vissandjée, & Marchildon, 2018). One of the defining features of Canadian Medicare is that it is a need-based model where health services are delivered to illegible people on a need basis rather than affordability being a criteria. This is realised through a publicly funded system where general taxation and public insurances cover healthcare and hospital costs (Martin et al., 2018).

Like most countries that are members of the Organisation for Economic Co-operation and Development. Canada faces an ageing population and fiscal constraints in its publicly funded programmes. Services must be provided across vast geography and in the context of high rates of migration and ethnocultural diversity in Canadian cities.

Canada also boasts of a robust healthcare system among the OECD countries with the average life expectancy of 82 which is well above OECD's average rate (OECD, 2020). According to the Canadian Institute for Health Information (CIHI), the country's expenditure on healthcare in 2019 amounted to S264.4 billion which constituted 11.6% of Canada's GDP in that year (CIHI, 2019). Among the OECD countries, Canada has one of the highest spending rate on individuals at CA$ 6,448, a testimony to the quality of care provided to its citizens. About 70% of the total healthcare expenditure in Canada is funded by the government and public sources, which has been consistent over the past two decades. The total expenditure on drugs and pharmaceutical constituted about 15.3% of the overall health expenditure (CIHI, 2019).

The United States' healthcare system does not bode well in comparison to other OECD countries despite the fact that it has one of the highest healthcare expenditures. The healthcare system is highly fragmented with various funding structures, most of which is administered through private insurers (Sezer & Bauer, 2017). Unlike the other reviewed countries' in this, there is no universal health coverage in the United States where healthcare coverage is financed through general taxation schemes. It is a highly decentralised system which is consistently a topic of discussion among politicians and policy makers to bring about some improvements (Sezer & Bauer, 2017).

According to Centres for Medicare and Medicaid Services (CMS), the overall healthcare expenditure in 2018 was a staggering $3.6 trillion which equates to $11,172 per person which is also projected to grow to $6.2 trillion by 2028. This amount constitutes 17.7% of the United States GDP (CMS, 2019). Federal government as well as state and local governments accounted for 44.8% of health expenses and the rest is from other sources such as households or private businesses (CMS, 2019). Prescription drugs and pharmaceuticals accounted for about 9% of total health expenditure. Despite huge healthcare expenditure, the United States average life expectancy is lower than other reviewed countries at 78 years (OECD, 2020).

Australia has one of the most efficient health care systems among OECD member countries. A recent survey conducted by the Commonwealth Fund's International Health Policy places Australia second after England from among 11 countries in terms of its health care efficiency (Schneider, Sarnak, Squires, Shah, & Doty, 2017). Nevertheless, the Australian health care system has its own complications and challenges which will be discussed further in this chapter. In 2017-18, Australia's total healthcare expenditure was AU$ 185.4 billion, two-thirds of which was funded by the Australian Government and state and territories governments (AU$ 77.1 and AU$ 49.5 billion respectively). The remaining was funded by the non-government sector such as private

health insurers or individuals (Australian Institute of Health and Welfare, 2018c). The current level of expenditure has increased by approximately 50% compared to AU$ 113 billion in 2006-07 (Australian Institute of Health and Welfare, 2019).

The health system in Australia is a combination of the market model and welfare state model which makes it a 'hybrid model' in which the government subsidies provide basic coverage for some health care expenses; individuals can purchase private insurance to cover the remaining expenses (Dixit & Sambasivan, 2018). The universal public health scheme in Australia is known as Medicare, which is funded through tax revenues and provides free health services in public hospitals and partially covers the costs of medicines and health professionals' services. Another health initiative is the Pharmaceutical Benefits Scheme (PBS) which provides a list of medicines for which consumers pay only a part of the costs (Australian Institute of Health and Welfare, 2018a). As mentioned earlier, Australia fares well in terms of health indicators at an international level, with an average life expectancy of 82.5 years which is well above the OECD's average of 80.2 years, making Australia the sixth-highest among the OECD member countries (Australian Institute of Health and Welfare, 2018d). Table 2.3 provides a comparison of the main features of Australia's healthcare system with those of the OECD average.

Table 2. 3 Comparison of Australia's healthcare features with OECD average

Source: OECD (2017; 2020)

Factor	OECD Average	Australia
Healthcare Expenditure Per Person	US $4,003	US $4,708
Percentage of GDP on Healthcare Expenditure	9%	9.6%
Percentage of Total Healthcare Expenditure on Pharmaceuticals	19%	14.7%
Government Coverage of Health Expenditure	36%	67%

As demonstrated in Table 2.3, the Australian Government covers a considerable amount of healthcare expenditure compared to the average amount among the OECD countries. This is one of the reasons for the provision of quality health services in Australia. In spite of the efficiency of the system, there are still challenges facing Australian pharmaceutical healthcare including a fragmented and complex approach to healthcare which will be discussed in later sections of this chapter (See Section 2.7.2). One of the objectives of the Australian national healthcare strategy is to create an integrated and harmonized approach to healthcare service delivery across the system in order to improve performance and quality. The use of improved technology has also been indicated in the national strategy to improve services (Department of Health, 2013). Pharmaceutical supply chain plays a significant role in healthcare industry in providing appropriate medicines and products to the right patients at the right place and time. Therefore, this study has focused on BDA adoption in the Australian pharmaceutical supply chain as a technology that would be capable of improving supply chain services and decision-making. The next section provides a summary of the main Australian pharmaceutical supply chain entities and relevant government regulatory agencies and initiatives relevant to this research.

2.7.1 Australian Pharmaceutical Supply Chain

Australian Pharmaceutical supply chain is a complex network of government and non-government entities and agencies. Figure 2.5 delineates a simple snapshot of the pharmaceutical supply chain players in Australia. It must be noted that the research focuses on the three main entities in the supply chain—namely manufacturers, wholesalers/distributors, and hospital pharmacies.

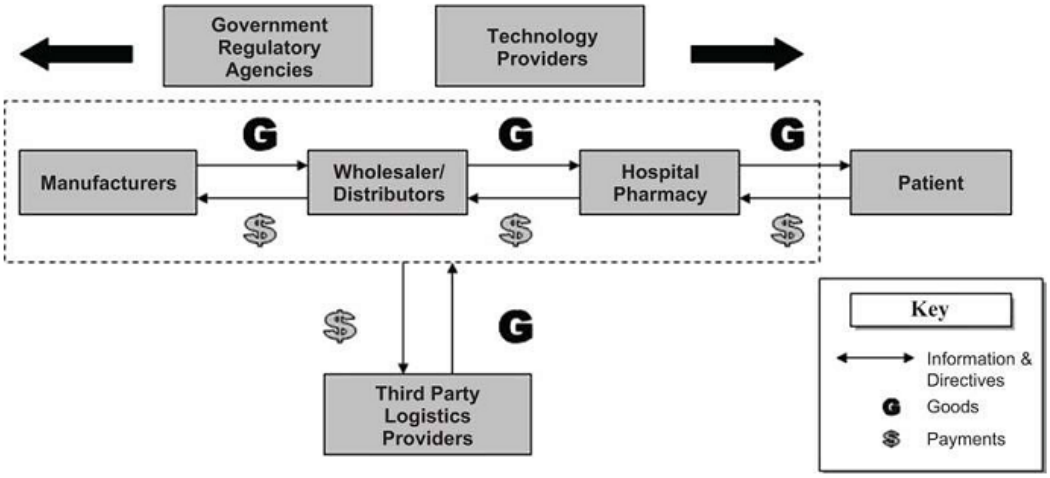

Figure 2. 5 Australian pharmaceutical healthcare supply chain

Source: Bhakoo and Chan (2011)

As Figure 2.5 demonstrates, this research treats these organisations equally without emphasising any of these entities in particular to create a balanced picture of common determinants of BDA in the supply chain. Along with these entities, government regulatory agencies and initiatives such as Health Purchasing Victoria (HPV), Therapeutic Goods Administration (TGA), and PBS also play a role in the activities of the supply chain entities. The aim of this section is to delineate the responsibilities of these entities and the role they play in the supply chain in order to outline the scope of this research.

2.7.1.1 Hospital Pharmacies

Hospitals play a key role in the delivery of quality health services. The scope of this research exclusively focuses on public hospitals. In 2017-18, there were 1,350 hospitals in Australia, 693 of which were public hospitals. The total government expenditure on public hospitals in 2017-18 was recorded at $71 billion (Australian Institute of Health and Welfare, 2019b). Public hospitals are funded by the Australian Government and state and territory governments, but it is the latter group which regulates public hospitals through 'Local Hospital Networks' that is composed of state and territory authorities who oversee the funding and management of public hospitals (Australian Institute of Health and Welfare, 2018a).

Expenditure on medicine was estimated at $20.8 billion of which over $11.5 billion was subsidized by the government through PBS (Australian Institute of Health and Welfare, 2018b; Pharmaceutical Benefits Scheme, 2018). These hospitals offer a variety of services and accordingly they require access to a wide range of medicines. Prescription medicines constitute a large segment of pharmacy products and as Australians' life expectancy continues to grow, there will be a sizeable ageing population who requires more medicinal products and services. A report by the Australian Treasury (2015) projects a growing demand for pharmaceutical products by 2055 and consequently more pressure on the healthcare system to fulfil the demand. Currently, 45% of medicine consumers are aged between 45 to 65 years and 20 per cent aged over 65 years (Richardson, 2018c). Since one of the objectives of the Australian National Medicines Policy (Department of Health and Ageing, 1999) is to facilitate timely and affordable medicines, the adoption of new technologies including BDA in the supply chain of pharmaceutical products gains more prominence. Hence, the need to investigate the determinants of BDA adoption in the pharmaceutical supply chain is quite timely.

2.7.1.2 Wholesalers/Distributors

The other important pharmaceutical supply chain entity is the wholesalers/distributors who form the link between manufacturers and hospital pharmacies in the provision of a wide range of pharmaceutical and medicinal products. There are currently seven wholesalers/distributors in Australia, three of which account for 80% of the total prescribed medicines sold in Australia (Richardson, 2018b). This research interviewed four wholesalers/distributors. The sales and distribution of PBS medicines constitute 47.5% of wholesalers' total revenue and the share of other medicines is 44.6% (Richardson, 2018b). In total, 85% of the pharmaceutical products in Australia are dispatched through wholesalers/distributors (Richardson, 2018a). PBS medicines' prices are heavily regulated by the government which decrease the wholesalers' margin as they have no control in setting up the prices. Wholesalers' market margin is also affected by PBS regulatory changes which have let them to focus more on non-PBS products and new markets, such as hospital pharmacies, as most of their products are distributed through the hospitals (Richardson, 2018b). To boost their financial benefits, wholesalers are considering new IT platforms and emerging technologies to improve their inventory and stock management in an attempt to upgrade their distribution centres. Technology is predicted to play a significant role in the industry in the next five years and IT platforms can enable wholesalers to establish a more efficient collaboration with their business partners for better visibility of their stock (Richardson, 2018b). This signifies the need for investigating the determinants of BDA adoption in pharmaceutical supply chain processes for better decision-making.

2.7.1.3 Manufacturers

Manufacturers in this study are both local and international organisations which are involved in the manufacture of pharmaceutical and medical products as well as pharmaceutical research and development activities. There are approximately 50 multinational manufacturing organisations in Australia (Richardson, 2018a). They produce both prescription and over-the-counter (OTC) medicines. Some manufacturers produce branded products for which they hold a patent, and therefore, such products are more profitable. Once the patent expires, the price significantly drops and the medicine becomes generic medicine. Branded manufacturers have a more reliable supply chain as they are the only producers of the drugs (Annabel, 2018). Similar to wholesalers, the changing regulatory framework, especially regarding PBS, has adversely constrained manufacturers' revenue as PBS seeks to reduce the medicines' price at an affordable level. The constraints on revenues play a key role in streamlining and improving the operational efficiency of the manufacturers where technology platforms have a role to play (Richardson, 2018a). Two multinational organisations in Australia have already established their own direct distribution model and this trend will likely be adopted by others. As technology will continue to influence operations at all level (Richardson, 2018a), BDA adoption can play a key role in improving manufacturers' forecasting models to improve their manufacturing planning process.

2.7.1.4 Health Purchasing Victoria (HPV)

HPV is a Victorian Government initiative established in 2001 which operates as an independent statutory body that helps public hospitals and health services in Victoria in procurement of health-related products through holding tenders to offer the best value. HPV also aims to create an efficient pharmaceutical supply chain through improved data availability based on which supply

chain decisions are made (Health Purchasing Victoria, 2017a). HPV is responsible for developing and implementing policies that drive the best value and also monitor public hospitals' compliance with the purchasing policies. They are also responsible for establishing and maintaining a database of purchasing data to foster the use of technology and data, share information, and improve pharmaceutical supply chain decision-making (Health Purchasing Victoria, 2017b). Some of their collected data is shared with supply chain partners to assist them in developing their demand forecasting. HPV has developed and fostered a data-driven culture through the development of reporting tools that are used to analyse purchasing data in order to increase efficiency and improve pharmaceutical supply chain operations (Health Purchasing Victoria, 2018). Thus, HPV has played a decent role in consolidating the pharmaceutical supply chain in Victoria.

2.7.1.5 Therapeutic Goods Administration (TGA) and Pharmaceutical Benefits Scheme (PBS)

As a part of the Department of Health, TGA is the national regulator of therapeutic goods (both prescription and OTC medicines and medical devices). TGA's function is to ensure the safety and quality of medical goods including all prescription and over-the-counter medicines and their compliance with the Australian standards before they are supplied to the market. The supply, import, and export of medicines are all regulated through TGA and then registered on the 'Australian Register of Therapeutic Goods'. There are currently more than 86,000 items on the registry (Therapeutic Goods Administration, 2019). A sponsoring company needs to apply to the TGA and receive their approval before importing or supplying their medicines into the Australian market.

PBS is also another Australian Government initiative which provides subsidized medicines. These medicines are first approved by the TGA and then a pharmaceutical company sponsors the medicine to be registered in the Australian Registry of Therapeutic Goods which means the medicine is safe to be sold in Australia. PBS provides affordable access to a wide range of medicines. In 2016-17, the Australian Government spent over $12 billion on PBS medicines (Australian Institute of Health and Welfare, 2018a).

2.7.2 Challenges of Pharmaceutical Supply Chain

The global pharmaceutical supply chain is fraught with several challenges which can affect the quality of supply chain operations, especially in the pharmaceutical sector. Australian pharmaceutical supply chain also shares these issues. Below is an outline of some of these challenges.

2.7.2.1 Unique Nature of Pharmaceutical Supply Chain

The nature of pharmaceutical industry is fundamentally different from other industries such as consumer products. The pharmaceutical products, particularly medicines, follow an extremely lengthy development period. This process is further compounded due to huge initial investments but low success rate because numerous clinical trials are required before the medicine is ready to be launched (Laínez, Schaefer, & Reklaitis, 2012). The manufacturing costs can also be exorbitant. For example, American pharmaceutical companies invested more than US$65 billion in research and development activities which accounted for one-fifth of their total sales in 2010 (Laínez et al., 2012). Compared to other industries, the pharmaceutical industry is also characterized by higher levels of drug/product ‘personalisation’ (Settanni, Harrington, & Srai, 2017) to ensure the product

fulfills the specific needs of patients. Therefore, customer satisfaction in the pharmaceutical industry requires a more complex supply chain (Moosivand, Ghatari, & Rasekh, 2019; Schneller & Smeltzer, 2006) which involves higher customisation and customer/partner involvement which adds further complication to pharmaceutical supply chain (Mathur, Gupta, & Dangayach, 2018). Given the sensitive nature of the pharmaceutical industry, its supply chain needs to ensure that the right medicines are delivered to the right patients at the right time and place to ensure acceptable customer service. Any disruption in the supply chain can have adverse consequences on the health and safety of patients. Therefore, many organisations hold large inventories to ensure product availability but it is not an ideal way to operate stock level (Mehralian et al., 2015). Holding excess inventory incurs costs to the supply chain partners.

2.7.2.2 Complex Supply Chain Planning and Coordination

As mentioned earlier, pharmaceutical manufacturing is conflated with issues relating to lengthy manufacturing time, drug personalization, and associated costs that complicate the supply chain operations. Therefore, pharmaceutical supply chain is generally marked by uncertainty (Pitta & Laric, 2004; Wang & Jie, 2020) which highlights the significance of optimising the supply chain operations in pharmaceutical industry. The uncertainty is more prominent in adjusting the anticipated demand and the actual market need (Shah, 2004; Wang & Jie, 2020). The manufacturing process is a lengthy task which involves several clinical trials before a drug becomes commercially viable. The process is likely to encounter a high failure rate because only one-fifth of clinical trials become commercial (Tollman, Morieux, Murphy, & Schulze, 2011). To effectively manage the demands, organisations primarily rely on market intelligence and historical data to develop medium and long-term forecasts for a time period ranging between three to 24 months (Merkuryeva, Valberga, & Smirnov, 2019; Shah, 2004). Organisations often hold large

inventories to safeguard against any unanticipated issues which might drive up the demand; however, the 'bullwhip effect' is still a common phenomenon in pharmaceutical supply chain, especially at the level of manufacturers (Moktadir et al., 2018; Shah, 2004). There is a considerable body of literature on the issue of bullwhip effect and lack of coordination in the supply chain and logistics; however, few of them specifically focus on the pharmaceutical industry with a holistic perspective. Those few examples have only considered either one entity in the supply chain or conducted a case analysis on one entity rather than the totality of the supply chain. Moktadir et al. (2018) have analysed risk management in the pharmaceutical supply chain sector in order to offer novel decision-making model. According to their research, risks associated with supply, stock shortages or lack of information sharing are deemed more important than financial or demand-related risks. They identify the bullwhip effect in demand-associated risks as being the least significant risk among their priority ranking. Nevertheless, the bullwhip effect makes it challenging for pharmaceutical companies to anticipate the exact demand, which may result in poor business performance.

Another similar research also focuses on the pharmaceutical supply chain in Italy which takes three organisations as its case study in order to investigate improving the supply chain performance and save costs in response to the government's reduction of healthcare expenditure. (Postacchini, Ciarapica, Bevilacqua, Mazzuto, & Paciarotti, 2016). They analysed several factors such as transshipment, inventory policies and the required service level. Then, an analysis was conducted on stock level, bullwhip effect and service level of the case studies followed by a Design of Experiment (DoE) analysis to determine the significance of different variables in improving the supply chain. The research identifies that the adoption of "reorder point policy (ECQ, Economic order Quantity)" can decrease the bullwhip effect.

Hoffman (2017) specifically focuses on the role of big data in alleviating the bullwhip effect on the supply chain in industries. Using system dynamics model, the variety, velocity, and volume of big data are simulated and it is concluded that the velocity aspect of big data plays a significant role in reducing the likelihood of bullwhip effect in supply chain. However, given that this research uses a simulation model, the main argument of the essay is founded upon the assumption that big data is already being used by industries and then the author goes on to study its impact on mitigating the bullwhip effect across only two entities in the supply chain, manufacturer and retailer. The author also concedes that the implementation of big data in industries is beset by numerous challenges and specifically mentions that these challenges should be further investigated to make any definitive conclusion about the role of big data in improving the supply chain processes.

Adding extra capacity is not a feasible option as market demand changes between the time the initial manufacturing process begins until the drug enters the market (Laínez et al., 2012). Furthermore, the upstream and downstream supply chain entities are not well coordinated in their supply and demand, which delays their responsiveness to market demands (Settanni et al., 2017). As an adverse consequence of this lack of coordination, the actual demand is either unknown or inaccurately identified (Privett & Gonsalvez, 2014). Lack of accurate information in pharmaceutical supply chain leads to poor decision-making (Low, Halim, Adhitya, Chew, & Sharratt, 2016). The combination of rigid regulations and lack of coordination can pose significant barriers to supply chain operations (Baoyang, 2018).

2.7.2.3 Increasing Regulations

A further barrier in the pharmaceutical supply chain is the existence of a highly stringent regulatory regime (Bravo & de Carvalho, 2015). The unique nature of this industry necessitates legitimate concerns over the quality and efficacy of products and supply and demand practices (Mehralian, Nazari, Akhavan, & Rasekh, 2014; Shah, 2004). As life expectancy and the consequent ageing population grows, the healthcare costs increase proportionally and the government is proactive to control and regulate the pharmaceutical sector (Hasan, Kow, Dawoud, Mohamed, & Baines, 2019; Shah, 2004). Regulations can be more cumbersome in case there are variations in different regions which is the case in Australia.

2.7.2.4 Fragmented Healthcare System

A further challenge is the fragmented and highly complex healthcare systems in some countries, especially Australia. The McKell report specifically cites the fragmented nature of healthcare industry in Australia which stands as one of the major barriers to implement and enhance big data analytics capability (McKell, 2016). This complexity arises due, in part, to a multitude of players with multi-objectives within the healthcare system (Hall, 2015; Macri, 2016). Lack of a unified system is mainly the legacy of a confederate system in which the federal, states and territories, and local governments have different, and sometimes overlapping roles and responsibilities in regulating, funding, and governing the system (Duckett, 2017; Glance, 2015).

The main players in the Australian healthcare system include the Australian Government, state and territory governments, local governments, and primary and secondary health providers such as hospitals and pharmacies which all comprise parts of the complex tapestry of the Australian healthcare system. The non-government sector is also involved in funding and managing private

hospitals and some health providers through private health insurance. Table 2.3 provides a summary of the main roles and responsibilities of the Australian Government, state and territory governments, and local governments in the healthcare system. As is evident, there are separate as well as overlapping responsibilities which highlight the lack of a uniform system.

Table 2. 4 Roles of Governments in Healthcare System

Source: Australian Institute of Health and Welfare (2018a)

Australian Government	State and Territory Governments	Local Governments
1. Developing national health policies 2. Administering Medicare 3. Funding states and territories for public hospitals 4. Funding Pharmaceutical Benefits Scheme 5. Funding health and medical research 6. Regulating private health services 7. Providing oversight of primary health care	8. Funding and managing public hospitals 9. Regulating and licensing private hospitals 10. Delivering public community based primary health services 11. Providing oversight of Local Health Networks (LHNs) 12. Delivering preventive services such as immunization programs	13. Providing environmental health-related services such as waste disposal 14. Delivering health promotion activities 15. Regulating and licensing private hospitals 16. Providing community and home-based health services
Shared Roles and Responsibilities		
1. Regulating pharmaceuticals and pharmacies 2. Educating and training health professionals 3. Regulation health workforce 4. Improving safety and quality of healthcare 5. Funding health programs and services		

An Australian Productivity Commission research report in 2015 identified the overlapping of responsibilities for service delivery, funding, and regulations as a significant cause of the system's complexity which leads to waste and inefficient health service (Productivity Commission, 2015). In a similar vein, a 2019 policy paper analysed numerous reviews of the Australian health system conducted by the government overtime and concluded that all the reviews consider "the current complexity of arrangements as a major impediment to improving … the efficiency of the

[healthcare] system" (Calder, Dunkin, Rochford, & Nichols, 2019, p. 2). The complexity and interactions between different governments and organisations result in fragmentations and poor coordination in healthcare service delivery (Department of Health, 2013).

2.8 The Development of Conceptual Framework

Organisations are generally faced with the dilemma of whether BDA adoption would be conducive to them or not (Hsu & Yeh, 2017; Verma & Chaurasia, 2019). To be equipped with BDA capability, organisations need to have a comprehensive understanding of what resources and capabilities they require and what impediments they are likely to face if they go on to adopt and implement BDA. In other words, what factors motivate or impede them for an innovation adoption. In line with the extant literature, this research considers BDA as an example of a technological innovation (Kwon et al., 2014; Lai et al., 2018). Therefore, the TOE framework has been chosen as an apt theory underpinning this study. The justification for the selection of the TOE framework is based on the fact that this framework offers the technology, organisation, and environment context that provides organisations a more detailed understanding of determinants and impediments of BDA adoption (Lai et al., 2018). There is a consensus among researchers that the TOE framework is a more comprehensive theory for the study of innovation adoption (Awa et al., 2017; Gangwar et al., 2014; Hossain & Quaddus, 2011; Oliveira & Martins, 2011). Consistent with the conceptual framework, the determinants of BDA adoption in the Australian pharmaceutical supply chain are broadly classified under these three categories: technology context, organisation context, and environment context. Informed by the extant literature on supply chain and BDA adoption, the following conceptual framework has been developed to identify and

analyse the BDA adoption determinants in the context of this research. Figure 2.6 represents the conceptual framework proposed for this thesis.

In the application of the TOE framework, these three contexts (technology, organisation, and environment) remain the same; however, factors under each context can differ from one another depending on the type of technology, the host industry, or the country in which the technology is being adopted (Baker, 2012; Lai et al., 2018). Due to the varying factors in each TOE context, researchers have called for broader application of the TOE framework in different industry contexts to further explore the determinants of BDA adoption in organisations (Awa et al., 2017; Dubey et al., 2016; Gangwar et al., 2014; Kwon et al., 2014). This research, therefore, is the first of its kind to utilise the TOE framework to investigate the BDA adoption determinants in the Australian pharmaceutical supply chain. It should be noted that as technology continues to grow and transform organisations and business models, the TOE framework will remain a relevant, potent and comprehensive model to study technology adoption in different contexts. Therefore, empirical research informed by this framework can continue to offer useful information in both academia and industry (Baker, 2012).

Based on the existing literature review, this research has selected the following two determinants for the technology context: relative advantage (Agrawal, 2015; Lai et al., 2018; Verma & Chaurasia, 2019) and technology compatibility (Agrawal, 2015; Verma & Bhattacharyya, 2017; Verma & Chaurasia, 2019). Relative advantage is defined as the expected operational and strategic benefits which are obtained from the use of a novel technology (Venkatesh & Bala, 2012). Compatibility refers to “the degree to which the innovation is perceived as consistent with the existing values, past experiences, and needs of the potential adopter” (Rogers, 2003, p. 240).

Consistent with the literature review, the determinants of BDA adoption in the organisation context in this research are top management support (Lai et al., 2018; Verma & Bhattacharyya, 2017; Verma & Chaurasia, 2019) and organisational readiness (Agrawal, 2015; Lai et al., 2018; Verma & Bhattacharyya, 2017; Verma & Chaurasia, 2019). Top management support refers to the degree to which top managers understand, appreciate, and support the adoption of a new technology (Chen et al., 2015; Ragu-Nathan, Apigian, Ragu-Nathan, & Tu, 2004). Organisational readiness is defined as "the availability of the necessary organisational resources for using BDA" (Chen et al., 2015, p. 18). These resources consist of both robust IT infrastructure and professional data analytics employees (Agrawal, 2015).

Finally, in the context of this research, the BDA adoption determinants in the environment context are government policy (Agrawal, 2015; Lai et al., 2018) and trading partner pressure (Verma & Bhattacharyya, 2017; Verma & Chaurasia, 2019). Government policy and regulation refers to the "governmental support [that] requires a firm to adopt new technology" (Hsu et al., 2014, p. 477). Trading partner pressure refers to the "pressure from upstream and downstream business partners which influences a firm to adopt new technology in order to maintain cooperative relationships" (Hsu et al., 2014, p. 477).

In investigating the determinants of BDA adoption, it is imperative for the organisations to know the opportunities and values that BDA can offer in each of the supply chain activities. Since supply chain comprises planning, sourcing, making, delivery, and return, this research is accordingly built upon the SCOR model which covers all the five processes. This study considers each process as an independent one and examines the influences of BDA on each process in the supply chain decisions. Previous studies strongly confirm the values that BDA adoption can offer to each organisation. These advantages include increased transparency and visibility along both

downstream and upstream supply chain operations, more accurate demand forecasting, improved collaboration and data sharing among trading partners, real-time identification of production issues, decrease in inventory fulfilment and delivery times, informed-decisions regarding both external and internal supply chain practices, and enhanced supply chain performance (Carter & Liane Easton, 2011; Tiwari et al., 2018; Zhu et al., 2018). However, there is still a lack of empirical research that can demonstrate how this value is obtained at the level of a supply chain (Wamba, Akter, Edwards, Chopin, & Gnanzou, 2015; Zhu et al., 2018). Therefore, the current study intends to investigate the impacts of BDA in each supply chain process in order to provide a comprehensive understanding of how BDA can influence and benefit each logistics process of an entity within the supply chain. The following conceptual framework (Figure 2.6) and research questions are developed, based on which this research is conducted.

RQ_1: What are the determinants of BDA adoption in the Australian pharmaceutical supply chain?

RQ_2: How does BDA improve decision-making across supply chain processes (SCOR processes: plan, source, make, deliver, and return) in the Australian pharmaceutical supply chain?

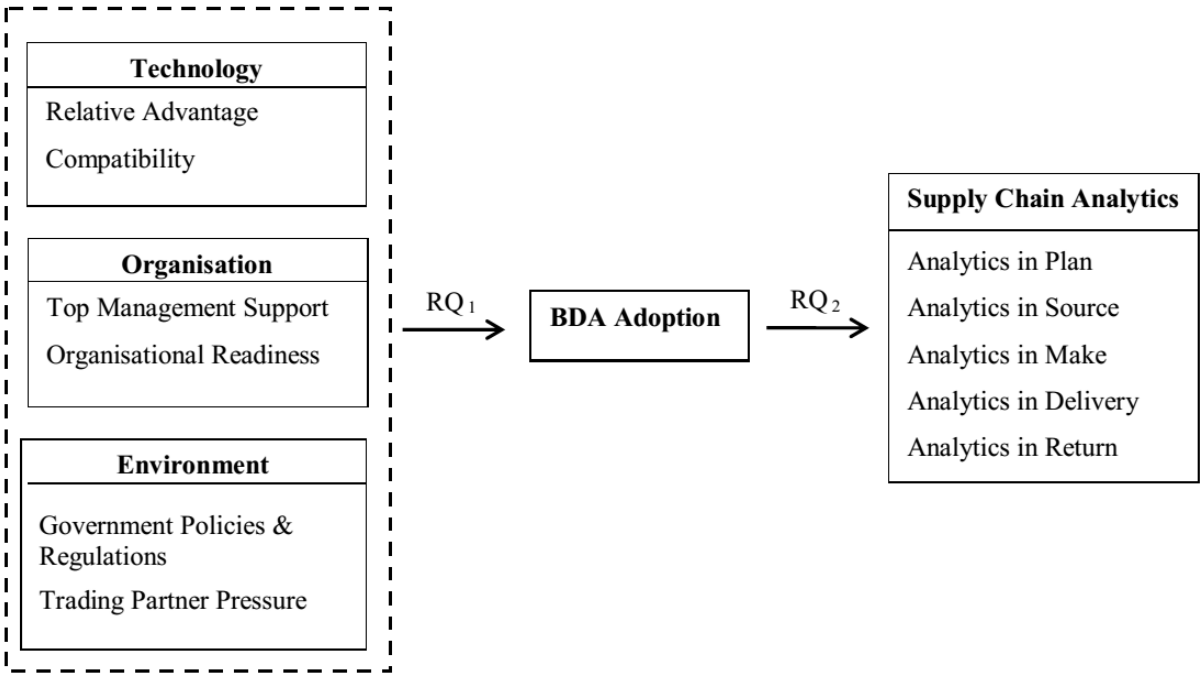

Figure 2. 6 Conceptual framework

2.9 Summary of Chapter

Data is being generated at an exponential pace from various sources in business environments. Given the fast pace of data generation, traditional statistical tools and methods cannot just manage to process and analyse such a voluminous amount of data to provide insights for meaningful decisions. Therefore, modern tools in BDA are required to store, manage and analyse big data meaningfully, especially in the supply chain. Industry practitioners and academics both agree that big data presents many opportunities rather than posing challenges. Big data can offer valuable information about customer behaviour, the market, and organisations' operational costs, from which numerous insights can be derived for better management of supply chain operations. Meaningful analysis of big data can help organisations increase their profits, explore potential markets, and improve customer services and operational efficiency. Big data is utilised in a wide

array of industries such as IT, manufacturing, healthcare, and logistics and supply chain. In the context of supply chain, big data analytics is used in SCOR processes to improve decision-making. BDA is also utilised in the pharmaceutical healthcare industry, but mainly in the clinical trials, in order to improve patients' care quality, develop new treatments, support clinical decisions, and reduce hospital costs. However, BDA is not deployed in the pharmaceutical healthcare supply chain which this thesis seeks to cover. This chapter also provided a detailed discussion of the TOE framework and the most prevalent determinants of innovation adoption. Following the discussion of the conceptual framework, a detailed overview of the Australian healthcare sector and its complexity was presented. The main actors in the Australian pharmaceutical supply chain were introduced and several pharmaceutical supply chain challenges were presented. This chapter concluded with an account of the conceptual framework and research questions.

Chapter 3

Research Methodology

3.1 Introduction

This chapter provides a detailed account of the methodology adopted for this research. Section 3.2 details the philosophical underpinnings of qualitative research methodology. Section 3.3 justifies the current research methodology and design which is case studies. Section 3.4 outlines the research design and Section 3.5 provides an account of case studies and the unit of analysis. Section 3.6 offers a detailed account of the data collection methods and Section 3.7 describes the data analysis methods implemented in this research. Section 3.8 provides an account of how research and data quality was ensured to maintain research rigor.

3.2 Philosophical Foundation of Research Methodology

This section of the chapter seeks to provide the philosophical underpinnings of qualitative research and justify why the topic of big data analytics (BDA) adoption in the pharmaceutical supply chain warranted the use of interviews in response to research questions. At the outset, it must be explicitly noted that this research adopts a constructivist approach to its research questions, and develops propositions in response to its findings through an interpretive (inductive) paradigm.

One of the most important aspects of research for scholars is the question of research methodology (Lee & Cassell, 2013). The dominant research paradigm in business and management studies has generally been ‘positivist’ which postulates an ‘objectivist epistemology’ (Su, 2018). According

to this paradigm, an external reality exists which can be studied and captured through a series of "generalisations and cause and effect linkages" that build knowledge or construct reality (Guba & Lincoln, 1994, p. 114). Positivism is a process of scientific discovery which mandates the detachment of the inquirer, knower, or researcher from the phenomenon under study to maintain objectivity—hence, the use of surveys or quantitative methods (Guba & Lincoln, 1994). Closely aligned with positivism, is the notion of grounded theory, espoused by Glaser and Strauss which postulates that theory can be derived from data through an inductive analysis of empirical data (Charmaz & Belgrave, 2015; Glaser & Strauss, 1967). In terms of definition and approach, grounded theory is akin to a positivist approach (Bryant & Charmaz, 2007).

From a research perspective, grounded theory can be divided into two categories: constructivist and objectivist. On the one hand, the first account is steeped in an interpretive tradition whereby meaning is co-constructed through the interaction of the researcher, participants, data, and data analysis. As a result, a researcher is deeply involved in the interpretation of data. On the other hand, the objectivist account, as the name suggests, is an objective account of an external reality which is discovered through data by a neutral observer or researcher (Su, 2018). The constructivist account accentuates the phenomenon under study as well as the role of the researcher in the construction of meaning, whereas the objectivist account highlights strict research procedures. Therefore, constructivists have favoured qualitative methods such as interviews to enrich and deepen their theories while objectivists have favoured quantitative methods such as surveys to achieve scientific objectivity. This research adheres to a constructivist paradigm through detailed interviews and case studies in an interpretive framework. Figure 3.1 demonstrates the philosophical underpinning of positivism.

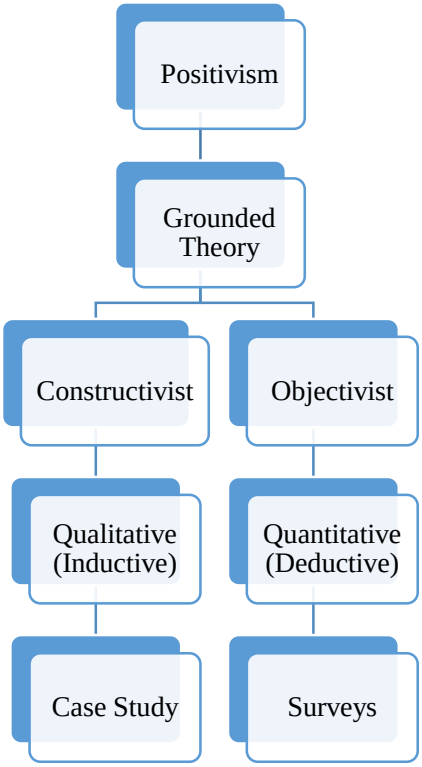

Figure 3. 1 Philosophical underpinnings of positivism

Source: Su (2018)

The use of qualitative research is also warranted in an attempt to build theories through the analysis of several case studies to construct theoretical propositions (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). This is achieved by discovering cause-and-effect relationships or patterns across cases through which the research develops propositions and logical arguments. This research also analyses the cause-and-effect relationship between factors such as data quality, skill levels, and government policies and regulations in the Australian pharmaceutical supply chain to develop propositions regarding the adoption of BDA.

Theory building is an area in which the operations management disciplines, in general, and supply chain management, in particular, can benefit from. Many scholars acknowledge the diversity of operations management as a newly emergent field that continues to borrow theories underpinning

other established disciplines (Amundson, 1998; Stock, 1997; Swanson, Goel, Francisco, & Stock, 2017). Scholars have also celebrated the novel contributions of other disciplines to operations management in diversifying its theoretical perspectives, broadening its intellectual reach, and aiding its developments in theory-building (Burgess, Singh, & Koroglu, 2006; Narasimhan, 2014; Walker, Chicksand, Radnor, & Watson, 2015). Therefore, the maturation of operations management and supply chain justifies research that is oriented towards theory building.

The use of a qualitative approach is also an attempt to redress a balance in operations management disciplines which are mainly dominated by quantitative approaches, surveys, and statistical modelling which better lend themselves to theory testing rather than theory building (Halldórsson & Arlbjørn, 2005; Burgess et al., 2006; Golicic et al., 2005; Reinecke et al., 2016; Stuart et al., 2002). Indeed, the novel nature of BDA in pharmaceutical supply chain requires developing propositions which this research attempts to do through interviews with the main pharmaceutical supply chain entities in Australia.

Research methodology also needs to take the nature of supply chain into account to ensure the methodology is well-suited to the phenomenon under study. The nature of supply chain is highly fluid which often intersects with other disciplines (Larson & Halldórsson, 2004). The phenomenon of supply chain is also highly complex or even 'messy' as it involves multiple organisations (Golicic et al., 2005; Näslund, 2002). Scholars often conceive of the supply chain as a network which is affiliated with many internal and external entities, therefore encompassing myriad players; the key aspect, however, is the multiplicity of networks and relationships (Houé & Murphy, 2016; Stock & Boyer, 2009). Furthermore, when the object of inquiry is relatively new or complex, researchers need to acquire an in-depth and comprehensive understanding of the phenomenon. To achieve this end, a qualitative approach is best suited to provide a detailed picture

of the dynamic or complex object of inquiry (Creswell, 1998). As discussed in Chapter 2 (See Section 2.7), the Australian pharmaceutical healthcare industry is highly fragmented and complex; as a result, a qualitative approach which utilises interviews is more effective to uncover the determinants of BDA adoption and its impact on the pharmaceutical supply chain.

As indicated earlier, a qualitative approach is an interpretive research paradigm which creates meaning or theories from raw data. When discussing the process of knowledge-making through a qualitative approach, Creswell emphasises that "knowledge is in the meanings people make of it; knowledge is gained through people talking about their meaning" (1998, 19). In other words, people are implicated in knowledge-making. This definition of knowledge-making aptly highlights the relevance of a qualitative approach and interviews in the context of supply chain. The researcher who is studying a dynamic, complex, or new phenomenon can experience the phenomenon in real-life contexts and discuss it with those who are directly involved. This practice is consistent with relational constructionism (Grandy, 2018) where meaning is co-constructed in relation to others involved in the context. Therefore, knowledge is dialectic (Cunliffe, 2008; Hosking, 2011), and created through interaction with others. Given the role of a researcher in interpreting data, there are concerns regarding compromising the objectivity of data (Grandy, 2018). In response, the researcher in this study has practiced reflexivity which involves critical reflection on the research context, interviews, the data, and analysis (Corlett & Mavin, 2018, p. 383) in order to eliminate bias and maintain objectivity. Therefore, multiple sources of data were used (See Section 3.6) to ensure that a 'critical distance' (Hayward & Cassell, 2018) is maintained. Additionally, this chapter presents a detailed account of the research methodology and research quality criteria to ensure research rigor.

Through an inductive analysis of data collected from interviews and discussions, a researcher can build a holistic picture of the supply chain operations and delve into the plurality of relationships and linkages between different entities. Houé & Murphy (2016) also confirm that a qualitative approach is best suited for investigating the complex nature of logistics networks and creating meaning and knowledge from the observed experiences of organisations. There is ample research that accentuates the values of a qualitative approach in investigating complex phenomena and relationships as it can provide a thorough interpretation of the phenomenon (Johnson, 2015; Mellor & Flint, 2009; Patton, 2015; Piore 2006). Considering the value that qualitative research potentially offers to the operations management field, many scholars revealed the paucity of qualitative research and absence of robust theory building in this area (Burgess et al, 2006; Ellram, 1996; Golicic & Davis, 2012; Mentzer & Kahn, 1995, Näslund, 2002; Sachan & Datta, 2005; Voss, Tsikriktsis, & Frohlich, 2002).

Despite the dominance of quantitative approaches and surveys in operations management, supply chain, and related fields, there has been an increasing utilisation of the qualitative approach in research (Barratt, Choi, & Li, 2011; Bluhm, Harman, Lee, & Mitchell, 2011; Buchanan & Bryman, 2007; Cassell, Cunliffe, & Grandy, 2018; Larson & Halldórsson, 2004; Reinecke, Arnold, & Palazzo 2016; Üsdiken, 2014). This growing trend addresses ongoing calls for qualitative research which can diversify and reinforce the theoretical foundations of the operations management discipline.

In light of the aforementioned arguments, the qualitative investigation of BDA in the Australian pharmaceutical supply chain is well justified. It must be further noted that a qualitative approach is typically used to study contemporary or emerging phenomenon to build relevant theories or propositions. Su (2018) specifically indicates that topics such as BDA, which are new, can be far

more effectively investigated through a qualitative approach. BDA is quite new and still in its adoption stage within the pharmaceutical industry. Thus, the researcher argues that a qualitative study will help reveal its status which is discussed in the next section with further examination of its suitability. Therefore, the literature presented warrants the use of this approach. The next section will present the justification of utilising a qualitative approach in the context of this research.

3.3 Justification of Research Methodology

The epistemological foundation of qualitative research was discussed in the previous section. Since the supply chain is a complex, dynamic, and often fragmented phenomenon with multiple networks and relationships, it renders a qualitative approach a more effective research paradigm. The BDA adoption in Australian pharmaceutical supply chain is investigated through the following questions:

> RQ_1: What are the determinants of BDA adoption in the Australian pharmaceutical supply chain?
>
> RQ_2: How does BDA improve decision-making across supply chain processes (SCOR processes: Plan, Source, Make, Deliver, and Return) in the Australian pharmaceutical supply chain?

In response to these research questions, the current research engages in qualitative interviews across 15 organisations through an interpretive lens. This section presents a detailed justification for this choice.

Two eminent proponents of qualitative research are Yin (2014) and Stake (2010). Despite marked differences in their approach, they have contributed significantly to the repertoire of research

methodologies. Both base their approach on constructionism which considers truth to be relative and dependent on observers' perspectives (Baxter & Jack, 2008). Truth is objective, but human subjectivity also plays a role in constructing it. This research predominantly subscribes to Yin's approach in its design and procedures.

To investigate BDA adoption in the Australian pharmaceutical supply chain, the main entities, comprising of manufacturers, wholesalers/distributors, and public hospital pharmacies, are investigated using multiple sources of data (See Section 3.6). Additionally, BDA is a new phenomenon in many industries and its adoption varies depending on the nature of each industry. In the Australian healthcare sector, BDA is utilised mainly in clinical health research (See Section 2.4) for predictive treatments, developing new medicines, or treatment methods. However, BDA is new to the Australian pharmaceutical industry. The adoption of BDA is highly context-dependent in the heavily regulated pharmaceutical healthcare industry which warrants the use of interviews with practitioners in this field to gain a comprehensive understanding of the phenomena (Seuring, 2008). In other words, phenomena cannot be separated from the context. Therefore, surveys cannot adequately investigate the phenomena (Yin, 2014, p. 33); hence the use of interviews.

A further justification for employing case studies is to answer questions pertaining to "why" and "how" (Yin, 2014) and while capturing a holistic view of the supply chain (Yin, 2014; Noor, 2008). The research questions in this study (See Section 3.3) seek to delineate 'how' the adoption of BDA in the pharmaceutical supply chain can improve decision-making across supply chain processes (SCOR processes: plan, source, make, deliver, and return). The selected cases are equally distributed across the pharmaceutical supply chain stream comprised of five manufacturers, five

wholesalers/distributors, and five hospital pharmacies in order to present a balanced and holistic picture of their activities in a real-world context (Australian pharmaceutical industry).

Yin (2014) categorises case studies into three classifications: exploratory, explanatory, and descriptive. This research falls into the exploratory category where a new phenomenon is explored in a real context. Given the lack of existing research on the adoption of BDA in the pharmaceutical supply chain, this research explores the determinants and benefits of BDA adoption.

Case studies with interviews can be used for various research purposes such as theory building, or refining existing theories. Voss et al. (2002) consider case studies to be conducive to exploring new phenomena for the purpose of theory building. According to this classification, case studies are also capable of revealing links between different variables in order to put forth propositions (Voss et al., 2002).

A final argument in favour of multiple-case studies is the legitimate criticisms laid against quantitative approaches and surveys in supply chain research. Näslund (2002) cites several issues with quantitative methods, including the inaccuracy or distortion of findings due to complicated quantitative methods, the inability of surveys to yield 'fresh perspectives', and the inadequacy of surveys to study 'change' in logistics organisations. In a similar vein, Stuart et al. (2002) also indicate that surveys cannot capture the complexity of operations management to make insightful comparisons. The adoption of BDA in the pharmaceutical supply chain constitutes a change in supply chain operations. Moreover, the Australian pharmaceutical supply chain is highly complex and fragmented which warrants the use of interviews to accurately capture the key variables, make insightful comparisons, and develop propositions.

3.4 Research Design

The design of the current study adheres to the three-stage model proposed by Yin (2014): define and design, collect and analyse, and analyse and conclude. Figure 3.2, which is adapted and modified from Yin (2014), delineates the research design and process.

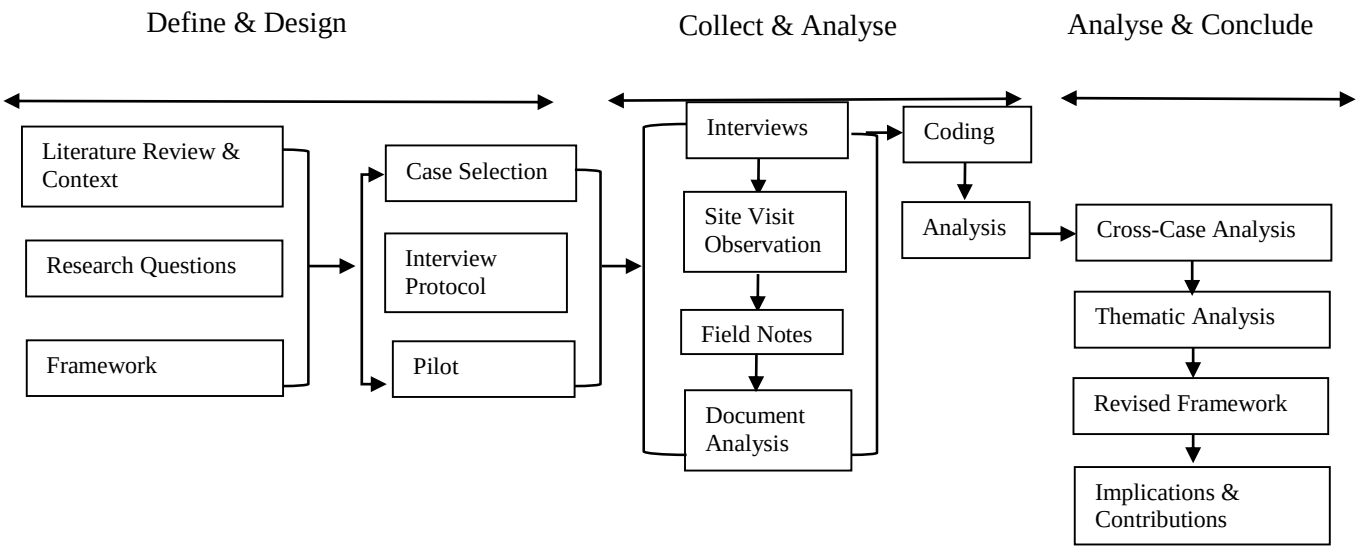

Figure 3. 2 Research process

Source: Adapted from Yin (2014)

3.4.1 Phase One: Define and Design

As demonstrated in Figure 3.2, the literature review of BDA was conducted to examine its definition, adoption determinants, and its benefits. In conjunction with the literature, the context of the Australian pharmaceutical healthcare industry was also investigated. The literature review revealed that BDA is utilised in the clinical research sector of healthcare to develop new medicine and innovative treatment and prevention methods (See Section 2.4). However, its potential is not explored in pharmaceutical supply chain. Therefore, the research gap was identified and two

research questions (See Section 3.3) were devised to investigate the determinants of BDA adoption and the positive contributions BDA can make to improve decision-making across pharmaceutical supply chain processes (SCOR processes: plan, source, make, deliver, and return).

In alignment with the proposed research questions, a conceptual framework was developed to explore the determinants of BDA adoption in the pharmaceutical supply chain and how it can benefit decision-making in supply chain processes. Following this phase, a set of interview questions (See Appendix A) was developed. Two pilot interviews were undertaken to test the suitability of the interview questions concerning its content and study objectives (Yin. 2014). The cases were selected from hospital pharmacies with two pharmacy directors who had extensive knowledge and experience in the pharmaceutical healthcare industry. The purpose was to assess the suitability of the interview questions and to gain a general understanding of common challenges on BDA adoption within the pharmacy and their partners. Following their feedback, further questions regarding drug shortages and data sharing were incorporated into the interview questions.

3.4.2 Phase Two: Collect and Analyse

The second phase focused on comprehensive data collection. A sample of 15 case studies with 20 interviews across the pharmaceutical supply chain was organised (See Tables 3.1; 3.2; 3.3; and 3.4). The sample includes five manufacturing organisations, five wholesalers/distributors, and five public hospital pharmacies. The informants held senior management positions with extensive knowledge and experience in the Australian healthcare system and pharmaceutical supply chain. The equal distribution of organisations across supply chain entities was intentionally designed to enable the researcher to follow a snowball technique where a partner could be identified for further

questioning. It also helped the researcher to build a holistic picture of their supply chain SCOR processes and identify the common determinants of BDA adoption. These cases, and the rationale for sampling, are presented in section 3.5. Furthermore, site visits, industry reports, and document analysis were undertaken to supplement the interviews. As the interviews progressed, the data was analysed to identify the patterns aligned with the initial conceptual framework.

3.4.3 Phase Three: Analyse and Conclude

Upon completion of a data collection phase, a thorough data analysis phase commenced. The findings were thematically examined to identify patterns and similarities with the help of N-Vivo software. The findings enabled the researcher to make insightful comparisons across cases (Baxter & Jack, 2008). The analysis was targeted to identify common determinants of BDA adoption and its potential benefits for the partners along the supply chain. The findings were compared with the extant literature, industry, and government reports. The results of the findings are presented in Chapter 4 and discussed in Chapter 5. Based on the research findings and supported by literature, a series of propositions are offered (Chapter 5).

3.5 Sampling and Justification

The sampling of organisations in research follows Yin's (2014) recommendation to adopt a 'replication logic'. In simple terms, cases can be considered as several experiments which all replicate the same findings.

One of the main criticisms levelled against qualitative research is its lack of clarity regarding sample sizes (Marshall, Cardon, Poddar, & Fontenot, 2013). While quantitative research uses power calculations to determine the required sample sizes, no such rigorous method is available in

qualitative research (Malterud, Siersma, & Guassora, 2016) since qualitative methods do not make statistical generalisations (Boddy, 2016). This is attributable to the fact that qualitative research does not seek to quantify opinions, but rather explores ideas in depth and analyses them from different perspectives (O'Reilly & Parker, 2012).

The key factor in determining the adequacy of sample size in qualitative research is the concept of 'saturation' (Fusch & Ness, 2015; Guest et al., 2006; Saunders, et al., 2018). This concept was introduced by Glaser and Strauss (1967) which indicates that interviews should continue until no new information or further insight emerges. Saturation is also defined as "the point in coding when [the researcher] find[s] that no new codes occur in the data" (Urquhart, 2013, p. 194), or when data does not reveal any new themes (Given, 2016). Determining the point of saturation in qualitative research is challenging as it requires "the researcher to combine sampling, data collection, and data analysis, rather than treating them as separate stages in a linear process" (Bryman, 2012, p. 18). This research also combines all these three stages, as demonstrated in Section 3.4, in order to identify the emerging patterns and themes as data was being collected. This also means that the number of interviews cannot be predetermined prior to the outset of the research. In this research, sampling was conducted through the snowball technique to recruit potential informants from different organisations with senior management positions and experience in the Australian pharmaceutical supply chain.

Determining the sample size based on saturation in qualitative research is mainly contextual and there is no consensus as to how many interviews are required. However, qualitative researchers suggest that a sample size of 10 to 30 is adequate for saturation (Boddy, 2016). In the context of this research, the point of saturation was achieved after 20 interviews across 15 organisations.

The interviews were conducted across 15 organisations which were selected to create an equal distribution across the three main entities in the Australian pharmaceutical supply chain (five manufacturers, five wholesalers/distributors, and five public hospital pharmacies). The sampling followed the logic that these combined entities form a supply chain starting from hospital pharmacies up to a manufacturer through the wholesalers.

Another consideration in term of sampling was the concept of 'information power' introduced by Malterud et al. (2016) which states that the more relevant information a sample holds, the smaller the sample size needs to be in the face of good quality information. This concept is closely related to the idea of 'saturation' as it mainly stipulates that once enough relevant information is collected, the sample does not need to be large. The concept of 'information power' is determined by five factors (Malterud et al., 2016) which determine if the sample size should be large or small (See Figure 3.3).

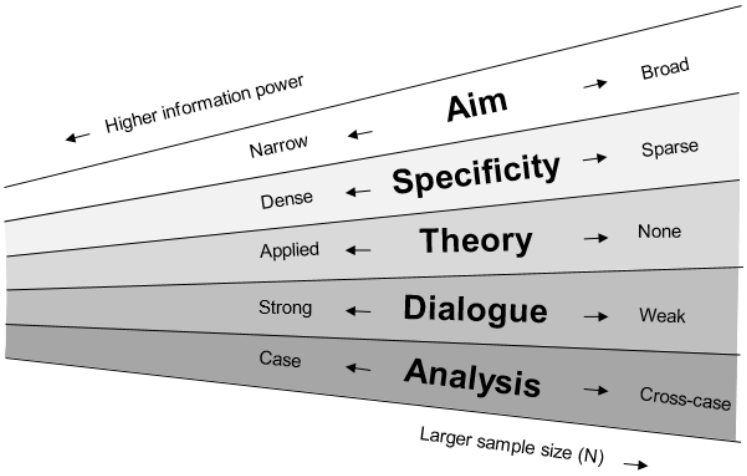

Figure 3. 3 Information power in qualitative sampling

Source: Malterud et al. (2016)

These five criteria have been applied in this research as detailed below.

- Study Aim: This criterion refers to the aim of the study which is either broad (requires larger sample sizes) or specific (requires smaller sample sizes). This study aims to investigate the determinants of BDA adoption in the Australian pharmaceutical supply chain and its influence on their supply chain processes which is a niche area and therefore not too broad. In effect, the narrow scope requires a smaller sample size.
- Sample Specificity: This criterion refers to the alignment of the informants' specific knowledge and experience with the topic of study. The more specific their knowledge (dense), the stronger the information power, and the smaller sample size. In this research, the informants were mainly senior managers with extensive experience in the pharmaceutical supply chain (See Table 3.4) which yielded very insightful information (See Chapter 4) that enhanced the information power.
- Established Theory: This criterion states that if research is based on a theoretical background in 'planning and analysis', the information power is stronger—hence no need for a larger sample size. This research is based in grounded theory and predominantly subscribes to Yin's (2014) approach in qualitative research planning and analysis (See Section 3.4).
- Quality of Dialogue: This criterion refers to the quality of interviews and sufficient information gained from them. The researcher in this study informed the interviewees of the research objectives and a research overview and the interview questions were emailed to informants prior to the interviews to ensure they had sufficient time to be familiarised with the topic and provide relevant and insightful information. The level of the informants' experience also positively contributed to the quality of dialogues.

- Analysis Strategy: This criterion refers to a single case or cross-case analysis. Cross case analysis requires a larger sample to yield information power. Malterud et al. (2016) recommend six to 12 informants for thematic cross-case analysis. This research used 20 informants for a thematic cross-case analysis.

Based on the arguments presented and literature used in qualitative research sampling, a sample size of 20 informants is well justified especially with regards to the concepts of saturation and information power. It must also be noted that in the sampling process, the concept of 'polar types' was also implemented (Miles & Huberman, 1994; Eisenhardt & Graebner, 2007). In each entity, one organisation, with unique or extreme characteristics, was selected in order to assess the validity of emerging theories. For example, one hospital exclusively specialised in cancer-related diseases; one wholesaler was a small-sized business while one manufacturer was local with a scale of operations smaller than the rest of the cohort.

The following section presents a brief profile of the organisations in which interviews were conducted. A summary of the organisations' profiles is presented in Table 3.1, Table 3.2, and Table 3.3. For detailed information about the interview dates and the informants' positions refer to Table 3.4.

3.5.1 Hospital Pharmacies' Profile

Hospital A: Hospital A is a large hospital in Melbourne with 4,000 employees, over 500 beds, and an annual budget of over AUS 771 million in 2018. Hospital A provided health services to over 60,000 inpatients and over 48,000 presentations to emergencies during 2017-18. The hospital offers a wide range of medical, psychiatric, mental health and surgical services including

cardiology, neurology, and haematology. The range of available services offer useful insights for this research as these services are dependent on other supply chain partners such as wholesalers. The first interview was conducted at this hospital with the Chief Pharmacist, who was responsible for medicine procurement.

Hospital B: Hospital B is a large specialist hospital in Melbourne which specialises in cardiology, infectious diseases, and mental health. The hospital has 640 beds, over 11,000 employees and annual budget exceeding AUS 1.88 billion. The hospital provided health services to 1,453,333 outpatients and recorded 226,315 emergency presentations in 2017-18. Two interviews were conducted at this hospital with two Directors of Pharmacies in two separate branches.

Hospital C: Hospital C is a large Melbourne-based hospital which specialises in spinal injuries and liver transplant and provides a range of other services such as mental health and cancer-related diseases. The hospital recorded 87,556 emergency presentations and performed 12,893 surgeries in 2017-18. Hospitals C's annual budget was AUS 935 million in 2017-18 with 880 beds and 8,657 employees. The informant was the Director of Pharmacy with over 15 years of experience in Australian healthcare and pharmaceutical products.

Hospital D: Hospital D is a large-sized hospital based in Melbourne with over 630 beds, employing over 9,000 people, with the annual budget of AUS 1.197 billion in 2017-18. Hospital D offers services such as lung and heart transplant, trauma, and rehabilitation, as well as specialty services for cancer care, respiratory, and cardiovascular diseases. The hospital provided inpatient services to 115,759 patients, performed 11,238 surgeries, and provided 159,678 specialist outpatient appointments in 2017-18. Similar to the aforementioned hospitals, Hospital D's wide

range of services required access to and the availability of large quantities of medicine. The informant's at Hospital D was the Director of Pharmacy.

Hospital E: Hospital E was a smaller-sized organisation in the Hospital Pharmacy entity with about 250 beds, 2,500 employees, and an annual budget of AUS 622 million in 2017-18. This hospital is a specialist hospital that only treats cancer-affected patients. The hospital recorded 300,000 cancer treatments as well as over 160,000 specialist appointments in 2017-18. This hospital solely specialised in treating cancer and cancer-related diseases, and was a polar type compared to hospitals which cater for a large number of patients with various diseases. The informant was the Director of Pharmacy.

A summary of the hospital pharmacies' case studies profile is presented in Table 3.1.

Table 3. 1 Profile of hospitals

Information	Hospital A	Hospital B	Hospital C	Hospital D	Hospital E
Location	Melbourne	Melbourne	Melbourne	Melbourne	Melbourne
Annual Budget	AUS 777 m	AUS 1.8 b	AUS 935 m	AUS 1.197 b	AUS 622 m
Employees	4,137	11,852	8,657	9,283	2500
Number of Interviews	1	2	1	1	1

3.5.2 Wholesalers/Distributors' Profile

Wholesaler/Distributor F: Wholesaler F is a subsidiary of a larger Australian company that provides healthcare services across many different areas. The annual revenue and employee information in Table 3.2 for this company is therefore inclusive of all subsidiary companies. Wholesaler F's headquarters is based in Melbourne and the company operates 11 warehouses across Australia. It has partnered with more than 550 manufacturers and service providers over

4,000 retail pharmacies and 1,300 hospital pharmacies, both public and private. Wholesaler F offered the opportunity for a site visit observation. Warehouses are highly automated and many operations, including inventory management, are automatically operated. Three informants, who were interviewed at Wholesaler F, occupied the following positions: State Manager, State Operation Manager, and General Manager Hospital Services. The informants were highly knowledgeable about the pharmaceutical supply chain in Australia and provided a comprehensive picture of the challenges of all entities in general and wholesalers in particular. Considering that they had highly automated warehouses, they were very insightful about the challenges and opportunities that BDA can offer.

Wholesaler/Distributor G: Wholesaler G is a small-sized Australian company whose headquarters is based in Sydney. This organisation services both retail pharmacies and hospital pharmacies, but only in a very small capacity. The selection of this company was based on polar type logic in comparison with other wholesalers/distributors. The informant was the Business Unit Manager who described the way they conduct their operations.

Wholesaler/Distributor H: Wholesaler H is a large Australian organisation which services over 1,200 retail pharmacies and hospital pharmacies across Australia. This company has over 850 employees with headquarters based in Melbourne. Their annual revenue in 2018-19 was $3.9 billion. Three informants were interviewed at Wholesaler H who held the following positions: Hospital Account Manager, Business Operations Manager, and Manager of Data and Analytics Platforms. The researcher also conducted a site visit operation at Wholesaler H's distribution centre in Melbourne which offered an overview of the way they conduct their day-to-day activities. Their processes were mainly manuals with workers walking through shelves and putting the required medicines in batches which were dispatched to hospitals. This organisation had recently

implemented a data analytics platform whose manager was interviewed in order to gain insight into their new platform.

Wholesaler/Distributor I: This organisation was the New South Wales branch of Wholesaler/Distributor F. The informant's position was the State Manager Hospitals in New South Wales. For more information about this organisation see Wholesaler/Manufacturer F.

Wholesaler/Distributor J: Wholesaler J is an Australian company which, according to the interviewee, has over 500 employees and had an annual revenue of AUS 1.9 billion in 2018. The researcher was not able to locate the annual revenue on their website and the financial and employee information cannot be corroborated. This company has seven warehouses across Australia which supply medical consumables and pharmaceutical products to hospital pharmacies and retailers. They also provide an online ordering system which provides online access to their inventory system. The informant was the Product and Purchasing Manager with nine years of experience at the current position.

A summary of the wholesalers/distributors' profile is presented in Table 3.2.

Table 3. 2 Profile of wholesalers/distributors

Information	Wholesaler F	Wholesaler G	Wholesaler H	Wholesaler I	Wholesaler J
Headquarter	Melbourne	Sydney	Melbourne	Melbourne	Melbourne
Annual Revenue	AUS 7.6 b	---	AUS 3.9 B	AUS 7.6 b	AUS 1.9 B
Employees	3,320	---	850	3,320	500
Number of Interviews	3	1	3	1	1

3.5.3 Manufacturers' Profiles

Manufacturer K: Manufacturer K is an Australian manufacturer whose headquarters and manufacturing site is based in Sydney. The company manufactures a range of products, particularly hospital specialties pharmaceuticals such as anaesthesia, antidotes, and anti-effective. The company also manufactures pharmaceutical ingredients and is sometimes contracted by other organisations to produce products on their behalf. Manufacturer K has also expanded its operations in New Zealand and more recently in the United Kingdom by establishing partnerships to distribute its products in those countries. According to its website, the company employs over 90 staff members and supplies over 65 brands of medicine. The informant was the National Sales Manager with over nine years of experience in this organisation. The selection of Manufacturer K serves as a polar type compared to the rest of the entities as this manufacturer is a small, local manufacturer which mainly supplies the Australian and New Zealand market. The current partnership with the UK is scheduled to begin in 2019-20.

Manufacturer L: Manufacturer L is a multinational manufacturing company with headquarters based in Switzerland. They have 26 manufacturing sites worldwide, and hundreds of research and development centres. The company employs over 94,000 staff members worldwide, with over 350 of them based in Australia. They recorded annual revenue of over CHF 56 billion in 2018. They manufacture a range of different products—especially in the areas of cancer, infectious diseases, and immunology. The Australian Branch of the company invests $44 million in research and development activities annually. The company provides 42 different types of medicine in the Australian market and it is the leading provider of cancer-related medicines in Australia by sales, with 28% of national cancer medicines sales. The informant holds the position of the Head of

Supply Chain with over five years at the current position and over 20 years of experience in the Australian pharmaceutical healthcare.

Manufacturer M: Manufacturer M is a British multinational company with headquarters based in London. The company operates 13 manufacturing sites across ten countries and has over 95,000 employees, with over 1,200 of them being based in Australia. It manufactures a range of products with a focus on respiratory and HIV medicines. The company is also a leading manufacturer of vaccines. Manufacturer M also produces many consumer healthcare products for pain relief, oral health, and skin health in Australia. The company reaped an annual revenue of £30.8 billion in 2018. The company's revenue in Australia was $921 million in 2018. The informant held the position of Customer Service & Logistics Lead - Intercontinental Supply Chain with six years of experience in the current position and approximately 20 years in the pharmaceutical supply chain.

Manufacturer N: Manufacturer N is an American multinational company with its headquarters located in Illinois. The company has over 50,000 employees globally and had annual revenue of US $11.1 b in 2018. The manufacturer operates roughly 50 manufacturing sites in 20 countries including one in Sydney, Australia. Manufacturer N operates in over 100 countries and has over 100 warehousing and distribution depots across the world, including Australia. Its key pharmaceutical products are medicine for kidney diseases and haemophilia. The informant was the Pharmacy Inventory and Systems Lead – ANZ with substantial experience in pharmaceutical healthcare.

Manufacturer O: Manufacturer O is an American multinational pharmaceutical organisation whose headquarter is based in New Jersey, USA. The company had annual revenue of US $42.3 billion in 2018, and has over 69,000 employees worldwide, with over 500 employees based in

Australia. Manufacturer O conducts business in over 140 countries and has been operating in Australia for about 60 years. Their main products include medicine for Alzheimer's, diabetes, cancer, HIV, infectious and cardio-metabolic diseases. The company manufactures over 80 types of medicine in therapeutic areas and women's health. The informant's position was the Key Account Manager with nine years of experience within this company.

A summary of the manufacturers' profile is presented in Table 3.3.

Table 3. 3 Profile of manufacturers

Information	Manufacturer K	Manufacturer L	Manufacturer M	Manufacturer N	Manufacturer O
Headquarter	Sydney	Basel/ Switzerland	London	Deerfield, Illinois	Kenilworth, New Jersey
Annual Revenue	---	CHF 56,846 b	£30.8 b	US $11.1 b	US $ 42.3 b
Employees (Worldwide)	90	94,442	95,490	50,000	69,000
Number of Interviews	1	1	1	1	1

3.5.4 Unit of Analysis

Defining the unit of analysis is an integral part of research (Dubé & Paré, 2003). However, in supply chain research, defining and selecting a unit of analysis has been fraught with problems. Supply chain is a complex network of organisations and service providers who are involved in delivering products and services to end consumers (Croom, Romano, & Giannakis, 2000; Hammervoll, 2016; Mentzer et al., 2001). Given this complexity, research in this domain has mainly focused on a single organisation as the unit of analysis rather than a whole supply chain network (Defee, Williams, & Randall, 2010). Systematic reviews of literature on supply chain management also reveal that a vast majority of research has taken either the organisation or a team within the organisation as their unit of analysis (Carter & Easton, 2011; Kaufmann & Saw, 2014).

The implication is that multiple case qualitative research, which aims to capture a holistic picture of the supply chain network, often fails to properly analyse the characteristics of the whole supply chain (Hammervoll, 2016). The issue around the choice of unit of analysis in supply chain management research has been identified and there have been calls to redirect the focus on the supply chain network rather than an individual entity (Frankel, Bolumole, Eltantawy, Paulraj, & Gundlach, 2008; Hammervoll, 2016). In response to this call, this research investigates the pharmaceutical supply chain as the unit of analysis. This three-echelon supply chain covers manufacturers, wholesalers/distributors, and hospital pharmacies. The inclusion of multiple entities in the supply chain network increases the validity of the research (Halldórsson & Arlbjørn, 2005). Research encompassing supply chain as a unit of analysis remains relatively rare in literature.

3.6 Data Collection and Sources

This research has relied on several data collection methods within a qualitative approach and data sources in order to create a thorough and in-depth picture of the phenomenon under study (Baxter & Jack, 2008) namely, the Australian pharmaceutical supply chain. The underlying logic of using different sources of data was to enhance the reliability of findings (Barratt et al., 2011). This research has used four common methods of qualitative research: interviews' transcripts, site visit observations, and document analysis (Silverman, 1993). Upon the completion of the data collection phase, the information was triangulated with data from site visits and document analysis to ensure the validity of the research. A detailed description of each method is presented in this section.

3.6.1 Semi-Structured Interviews

The primary source of data in this research was interviews with 20 informants across 15 organisations directly involved with the pharmaceutical supply chain. Research interviews are generally classified into three categories: unstructured, semi-structured, and structured (Schwandt, 1997). Structured interviews are rigid with standard closed questions; semi-structured interviews utilise open-ended questions with a range of possible answers to questions; and unstructured interviews, which are very fluid with open-ended questions and are mainly used to gather basic or foundational information (Given, 2008). Yin (2014, p. 183) also broadly defines interviews as "guided conversations" rather than a rigid line of inquiry. The interviews in this research are semi-structured with open-ended questions. A semi-structured interview is akin to a guided conversation which follows a set of open-ended questions but can also be guided by the informants' comments rather than the researcher's dictation. Such interviews are aimed at establishing 'rapport' and allowing the researcher more flexibility to delve into the topic of inquiry (Smith & Osborne, 2009). The benefit of this kind of interview is in both allowing informants to express their views and also enabling the researcher to exercise a degree of control in pursuing relevant information.

The interview questions were devised, based on a literature review and the conceptual framework. An overview of the research and the interview questions were sent to interviewees via email a few days in advance to familiarise them with the research objectives and the questions. A consent and confidentiality agreement was also sent to assure them that their name and organisation's identity will remain anonymous. This approach helped gain the informants' confidence and build trust which proved conducive to creating a relaxed interview atmosphere and eliciting insightful information (Gill, Stewart, Treasure, & Chadwick, 2008; Stuart et al., 2002). The informants were also notified of the potential length of the interviews, ranging from 60 to 90 minutes. This allowed

them to arrange their schedules to leave sufficient time for the interviews. It also precluded the risk of having 'uncommunicative interviewees' who might wish to quickly finish the interview by giving very succinct answers (King, 2004a). All the interviews were conducted on-site, except for two telephone interviews with Wholesaler/Distributor I and Manufacturer L whose informants were based in Sydney. Time and cost disadvantages (Stuart et al., 2002) did not allow the opportunity for in-person interviews in these two specific cases. The informants were highly knowledgeable about the pharmaceutical supply chain and held senior positions with extensive experience which enabled the researcher to explore the object of inquiry from multiple perspectives and alleviate concerns of bias (Eisenhardt & Graebner, 2007). Table 3.4 presents a profile of the informants and the data sources used for each case study.

King (2004a) recommends starting interviews with easy-to-answer questions before delving into more specific questions. The interviews started with general questions about the informants' level of experience, job roles and responsibilities, and their organisations' profile. The next level of questions centred on their supply chain activities and related processes (SCOR processes: plan, source, make, deliver, and return) and the challenges they faced in this regard. The informants unanimously agreed that drug shortage was an issue in the Australian pharmaceutical supply chain (See Section 4.3.1). The next series of questions focused on their level of technological maturity, and their collaboration with other supply chain entities. The final series of questions focused on their familiarity with BDA, the determinants of BDA adoption, and the positive contribution it would make to their supply chain processes.

With the approval of the interviewees, all the interviews were digitally recorded to accurately capture what was stated (Voss et al., 2002; Yin, 2014). The researcher also took notes during each interview and reviewed them prior to the subsequent interview(s). This enabled the researcher to

probe deeper into emerging areas or gaps which were not sufficiently addressed in the previous interviews (Voss et al., 2002). The field notes also proved useful in identifying similar patterns or themes throughout the interview process.

Following each interview, a ‘member check’ was conducted where the highlights of the interview were presented via email to informants to verify their authenticity (Stake, 2010). A returned email with verification was received from the informants. As a final step, a thank-you note was also sent to the interviewees with a request to introduce other potential candidates for further interviews if possible. A snowball technique was used to gain contacts from other informant organisations placed at the same level or higher up in the supply chain.

Table 3. 4 Informants' profile and data sources

No.	Organisation	Interview Date	Informant	Data Source
1.	Hospital Pharmacy A	5 Oct 2018	Chief Pharmacist	Interview Website Materials Annual Report
2.	Hospital Pharmacy B	22 Oct 2018	Director of Pharmacy	Interview Website Materials Annual Report
3.		29 Oct 2018	Director of Pharmacy	
4.	Hospital Pharmacy C	19 Nov 2018	Director of Pharmacy	Interview Website Materials Annual Report
5.	Hospital Pharmacy D	18 Dec 2018	Director of Pharmacy	Interview Website Materials Annual Report
6.	Hospital Pharmacy E	09 Jan 2019	Director of Pharmacy	Interview Website Materials Annual Report
7.	Wholesaler/Distributor F	13 Nov 2018	State Manager VIC & TAS	Interview Site Visit Observation Annual Report Website Materials
8.		30 Nov 2018	State Operation Manager VIC	
9.			General Manager Hospital Services	
10.	Wholesaler/Distributor G	29 Nov 2018	Business Unit Manager	Interview
11.	Wholesaler/Distributor H	5 Dec 2018	Hospital Account Manager	Interview Site Visit Observation Annual Report Website Materials
12.		7 Dec 2018	Business Operations Manager	
13.			Manager of Data and Analytics Platform	
14.	Wholesaler/Distributor I	15 Jan 2019	State Manager Hospitals NSW	Interview Annual Report Website Materials
15.	Wholesaler/Distributor J	7 Feb 2019	Product and Purchasing Manager	Interview Website Materials
16.	Manufacturer K	27 Nov 2018	National Sales Manager	Interview Website Materials
17.	Manufacturer L	27 Nov 2018	Head of Supply Chain	Interview Website Materials Annual Report
18.	Manufacturer M	19 Nov 2018	Customer Service and Logistics Lead – Intercontinental Supply Chain	Interview Website Materials Annual Report
19.	Manufacturer N	12 Dec 2018	Pharmacy Inventory and Systems Lead – ANZ	Interview Website Materials Annual Report
20.	Manufacturer O	10 Dec 2018	Key Account Manager	Interview Website Materials Annual Report

3.6.2 Transcripts

Transcripts provide an accurate record of the interviews and help avoid researcher bias (Yin, 2014). The recordings were sent to a professional transcriber immediately after each interview. The transcriber had extensive experience with supply chain interview transcriptions. An overview of the research summary and a list of commonly used terms were also emailed to acquaint the transcriber with the content. As had been previously agreed, the researcher received the transcripts within four or five days. Each transcript was meticulously checked against the recordings to ensure the information was accurately captured. This enabled the researcher to correct any inaccuracies. For instance, the names of some software programs were inaccurately transcribed but were rectified upon inspection. Furthermore, the transcripts were lightly edited in order to maintain their authenticity and convey the conversational sense of the interviews. The final drafts were imported to N-Vivo software for coding and analysis. N-Vivo is a software that helps researchers analyse qualitative interviews and create codes, sub-codes, categories, and sub-categories based on emerging themes and patterns which proved immensely helpful for thematic analysis. The N-Vivo query function was also effective in finding similar patterns and keywords.

3.6.3 Site Visit Observations

Site visit observations are a very useful form of data collection method which can provide a richer picture of the research topic. Observation methods are classified into four categories (Burgess as cited in Waddington, 2004; Näslund, 2002):

- Complete Participant: The participant's role as a researcher is completely concealed and he/she is completely involved in interactions.

- Participant as Observer: The participant's role as a researcher is disclosed to the group and he/she is completely involved in interactions.
- Observer as a participant: The observer's role as a researcher is disclosed, but he/she has limited interaction with the group under study.
- Complete Observer: The observer's role as a researcher is completely concealed and he/she has no interaction with the group under study.

The researcher in this research had the opportunity to visit two sites: Wholesaler/Distributor F and Wholesaler/Distributor H, adopted the role of 'observer as participant', and was given a guided tour of the warehouse at these two sites. Wholesaler/Distributor F was a highly automated warehouse where stocking and processing orders were automated. The tour guide and the Operation Manager provided a complete description of their supply chain activities from the stage where medicines are received from manufacturers until the stage they are dispatched and delivered to hospitals. Wholesaler/Distributor F mainly relied on manual processes where workers on the warehouse floor manually processed the orders and put them in totes to be delivered to hospitals. Additional questions about their inventory system and supply chain activities were asked and detailed notes were taken during the visits. The site visit observation helped the researcher to observe these organisations' activities in real-life situations and create a more detailed portrait of their activities. These notes were imported into N-Vivo to supplement the interview transcripts.

3.6.4 Documents and Reports

Document analysis is an important aspect of qualitative research (Prior, 2008). Several types of documents were used to supplement the data collected through the interviews and site visits. These

documents and reports have been used and cited in Chapter 5. The source of these documents is presented in this section:

- Government Reports: Health Purchasing Victoria, Productivity Commission, Senate Inquiry Reports, Australian Institute of Health and Welfare, Department of Industry, Innovation, and Science, and Medicines Australia.
- Industry and Research Report: Price Waterhouse Coopers, McKell Institute, Victoria University, Mitchell Institute, World Economic Forum, Common Wealth Scientific and Industrial Research Organisation (CSIRO), and McKinsey.

These documents provided an invaluable source of information to validate the interview findings.

3.7 Data Analysis Procedure

This section focuses on a detailed account of the different data analysis methods employed in this research. It must be noted that as the data collection phase was in progress, the researcher was simultaneously involved in data analysis. At this stage, the focus was on broadly identifying recurring patterns and themes in interviews and transcripts in order to facilitate the formal data analysis stage after the completion of data collection. A methodical approach was adopted after all the data was collected and imported into N-Vivo software.

The data analysis phase is one of the most challenging aspects of research as a large amount of raw information needs to be analysed (Houé & Murphy, 2016; Stuart et al., 2002) in order to reveal themes and create an insightful narrative. To facilitate the process, the researcher followed the recommendation of Houé and Murphy (2016) to create a summary of each interview transcript in

order to concisely capture the highlights which were subsequently used to cross-check against other interview transcripts and provide an overview of a common pattern across all 15 cases.

In analysing the interview data, Yin (2014) suggests four strategies: (i) using theoretical propositions, (ii) working your data from the 'ground-up', (iii) developing a case description, and (iv) examining plausible rival explanations. This research relied heavily on the second strategy, working the data from the 'ground-up', as this approach is more aligned with grounded theory and inductive method. Emerging themes or concepts were identified and further researched. An example is the issue of drug shortages resulting from a fragmented pharmaceutical supply chain (See Section 4.3.1).

The point of inductive research analysis is to provide a detailed analysis and interpretation of the phenomenon through 'thick description' which refers to a detailed interpretation of the phenomenon to reveal its interconnections and complexity (Stake, 2010). The analysis process was guided by different analytic methods such as coding, thematic analysis, and cross-case analysis which will be detailed in this section.

3.7.1 Coding

One of the data analysis methods used is data coding. This research followed the guidelines and methods prescribed by Saldaña (2013) in coding and categorising data to lead to theories. Saldaña (2013, p. 3) defines a code as "a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data." In other words, a code is simply a label or descriptor that requires further interpretation (King, 2004b). Coding is essentially a 'data reduction' method (Vaismoradi, Jones, Turunen, & Snelgrove, 2016). Data reduction, in turn, is defined as "the process of selecting, focusing,

simplifying, abstracting, and transforming data" (Koulikoff-Souviron & Harrison, 2005, p. 274) in order to narrow down the data, reveal insights, and facilitate analysis (Vaismoradi et al., 2016).

This research used N-Vivo software to facilitate the process of coding and analysing data. The initial stage of coding was relatively broad and the open coding technique (Charmaz, 2006) was solely used to identify broad concepts during the data collection phase. In this phase, keywords such as 'technology', 'data', and 'financial', were used as code labels. These codes were put under each research question category. Following Saldaña's (2013) guidelines, the second cycle of coding was conducted upon the completion of the data collection phase where the codes were reconfigured, and sub-codes were developed. They were categorised based on similar concepts or causal relationships. This phase was interpretive in nature. The categories were subsequently divided into sub-categories based on identified concepts and patterns relating to each research question. An example of coded data is presented in Table 3.5.

Table 3. 5 Examples of coded data

Code Category	Examples
Relative Advantage	*If BDA is available to you, then you're making decisions a lot quicker and essentially, you're saving time for people. You'd assume that you'd be saving money because there would be cost savings to be had wherever it is in the supply chain. I'd assume there is waste that we don't see due to the fact that people are having to manually obtain that data through multiple platforms or meetings or desk work, versus if the BDA was available to you.*
Top Management Support	*I think managers in general understand the efficiencies that could be gained for their own businesses for some significant upfront investment [in BDA adoption] that would generate long-term automation and savings.*
Skilled Human Resources	*There is a specific functional area which manages the analytics and the systems in terms of data warehousing and report generation, and that team actually does the job. They constantly have sessions for training whenever they upgrade, something for all the people who have got access to write reports or even use the reports. … And they would make sure that the end users are properly trained to use such systems to get data that they're usually looking at. So, the answer to the question is definitely there is a lot of resources put aside to manage that and time as well to make sure that people are properly trained.*
Robust IT Infrastructure	*We have our own IT department that manages the maintenance of our tools and infrastructure, so we can actually access the data on a regular basis. From within the data, we have some already prepared templates that is produced so that we can actually check the temperature of the business. So there are certain reports that come out on a daily basis and senior execs to junior people. They actually watch it to see things like our service levels, our field rates etcetera, how we are going against our procurement versus what we are selling. So, there are some tools there which have been created internally and we use them on a regular basis.*
Government Policies and Regulations	*We are operating in a very highly regulated environment because we are a pharma, and sometimes there might be some requests from regulatory affairs or somewhere like TGA that might need specific things, so we would look at upgrading or providing such sort of information through and upgrade to the system.*

It is helpful to draw a distinction between code, category, and theme. As discussed earlier, a code is a label attached to a section of raw data. Codes are, then, regrouped into larger categories which provide a description for theme. A category provides an explicit explanation or description of interview information (Vaismoradi et al., 2016, p. 102). A theme, however, is a product of codes and categories (Saldaña, 2013). It is an implicit reality that requires a high level of interpretation to be fleshed out. It confers deep meaning to and unifies all the data, hence its 'generality' (Vaismoradi et al., 2016). Theories emerge from themes and this requires a high interpretive level.

To put it in simple terms, data is first converted into codes/sub-codes, followed by categories/subcategories, then themes, and finally theories. Figure 3.4 from Saldaña (2013) is a cogent and concise visual representation of this process.

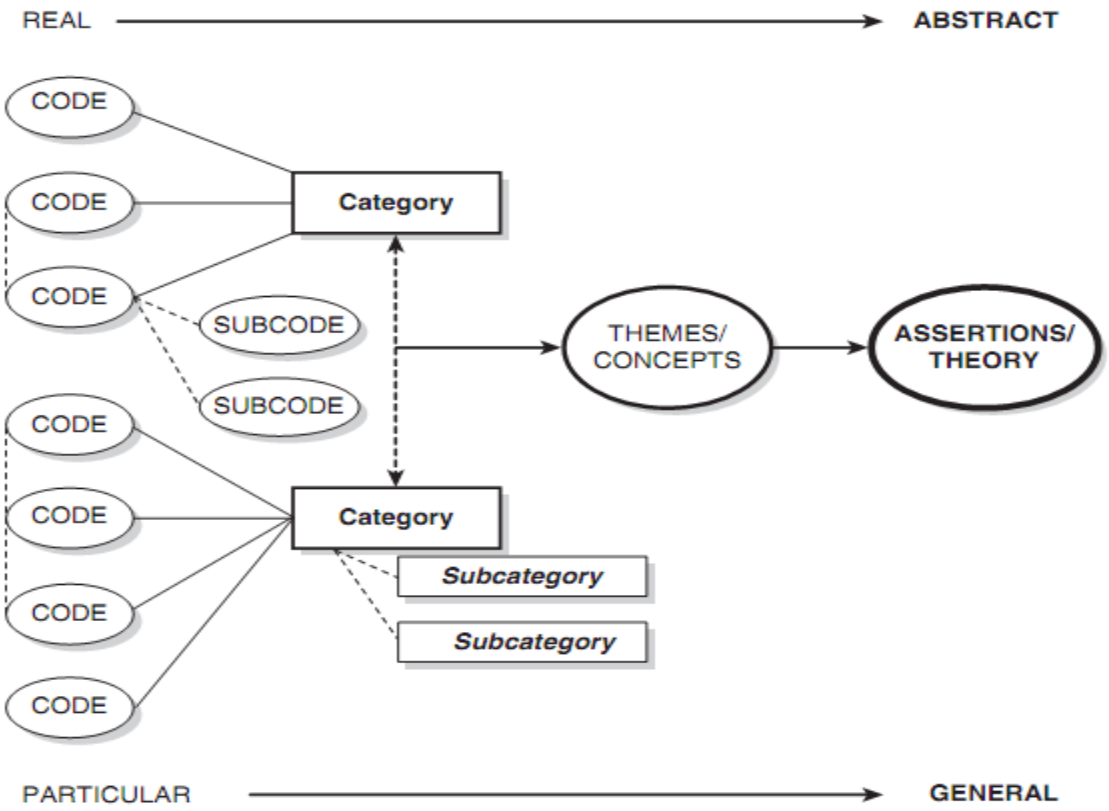

Figure 3. 4 Code to theory model in qualitative research

Source: Saldaña (2013)

The researcher relied on different types of codes to extract meaningful themes from the interview transcriptions and other sources of data. What follows is a brief description of some of the utilised coding methods which were prescribed by Saldaña (2013).

- Attribute Coding: This coding method was used to record essential demographic information about case studies and informants (See Table 3.1; Table 3.2; Table 3.3; and Table 3.4).
- Magnitude Coding: This method was used to register the frequency of agreement among participants regarding the identified patterns in numerical form. This method provides very basic statistical information for the research (See Table 4.1).
- N-Vivo Coding: This method is also called 'verbatim coding' where a word or phrase from the data is used as a label. N-Vivo coding was extensively used in the initial stages of data collection and data analysis to provide an overview of the most commonly used words or concepts related to research questions. Some of the code labels included technological infrastructure, drug shortage, and skills.
- Pattern Coding: This method was used after the initial phase of coding in order to group similar concepts together. Similarly, coded data were placed in the same categories under an umbrella term which captured the meaning of all the contained data. This was particularly helpful in identifying emerging themes. Some of the recurring patterns included relative advantage, top management support, skilled human resources, robust IT infrastructure, and government policies and regulations.

It should be further noted that the aforementioned methods were few; yet, they were the most commonly used coding methods. The researcher also adopted a flexible coding strategy to be able to analyse and revisit the data to examine emerging themes. Throughout the process, N-Vivo proved a highly effective tool in analysing data, especially the query capability and the ability to create simultaneous coding (assigning multiple codes to the same text).

3.7.2 Thematic Analysis

In analysing a qualitative research, the two dominant analysis approaches are content analysis and thematic analysis. These two terms are sometimes used interchangeably as the boundaries between them are relatively blurred (Viasmoradi, Turunen, & Bondas, 2013). Content analysis identifies patterns of data and describes their relationship and frequency (Braun & Clarke, 2006; Vaismoradi, Turunen, & Bondas, 2013). Thematic analysis, on the other hand, identifies and analyses themes and provides detailed interpretation. (Boyatzis, 1998; Braun & Clarke, 2006). While content analysis is more conducive to quantitative research, thematic analysis is more closely aligned with the interpretive paradigm of qualitative research (Braun & Clarke, 2006; Vaismoradi et al., 2013). Therefore, in line with the constructivist underpinnings of the current research, thematic analysis was adopted as an approach. In this method, the researcher analysed and identified similar patterns and themes in the raw data to develop theories in "an inductive or bottom-up" way (Braun & Clarke, 2006, p. 83). Thematic content analysis can focus on explicit (semantic) data or implicit (latent) data (Boyatzis, 1998; Braun & Clarke, 2006). Vaismoradi et al. (2016) provide a cogent description of these two levels where latent content relates to themes while manifest or explicit content relates to categories. This is consistent with the definitions of 'category' and 'theme' presented in section 3.7 where category (manifest content) is a description of explicit data and theme (latent content) is an analysis of that category which provides a richer understanding of the phenomenon. To facilitate thematic analysis, a pattern matching method (Yin, 2014) was followed where similar patterns and themes were identified based on their frequency, similarity, and causation. This method was particularly helpful in analysing the data pertaining to Research Question 1 where the determinants of BDA were identified and analysed (See Section 4.2). The process of thematic analysis prescribed by Braun and Clarke (2006) are detailed in Table 3.6.

Table 3. 6 Thematic analysis process

Source: Adapted from Braun and Clarke (2007)

Phase and Description	Application in this Research
Familiarising yourself with your data: Transcribing data, reading and rereading the data, noting down initial ideas.	Transcribing data, summarising transcripts and identifying highlights, and reviewing the transcripts and interview notes.
Generating initial codes: Coding interesting features of the data systematically across the entire data set, collating data relevant to each code.	Conducting a first coding cycle based on key words and frequency across all 20 transcripts and field notes, creating general themes such as human resource, skills, access to technology, financial constraints, information sharing, etc.
Searching for themes: Collating codes into potential themes, gathering all data relevant to each potential theme.	Conducing the second cycle of coding, identifying and categories similar themes into categories and sub-categories such as determinants of BDA adoption across all cases
Reviewing themes: Checking if the themes work in relation to the coded extracts and the entire data set, generating a thematic map.	Putting the themes in codes categories and sub-categories, comparing and contrasting them across all entities, creating tables to show the level of agreement
Defining and naming themes: Ongoing analysis for refining the specifics of each theme and the overall story that the analysis tells, generating clear definitions and names for each theme.	Conducting a rigorous revision of themes and codes, refining them and analysing rival explanations, creating the final theme categories and sub-categories
Producing the report: The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating the analysis back to the research question and literature, producing a report of the analysis.	Reviewing and supporting the findings with the literature review and industry and government reports, developing propositions and implications, writing the discussion chapter.

3.7.3 Cross-Case Analysis

A highly effective data analysis method is a cross-case analysis where patterns and concepts were examined across different cases. Voss et al. (2002) and Meredith (1998) consider cross-case analysis as a necessary step to enhance the generalisability of research findings and conclusions. Upon the identification of concepts and patterns, these concepts were first compared and contrasted among cases within an entity (i.e. manufacturers, or wholesalers/distributors, or hospital pharmacies). This helps to check whether these concepts also exist across cases within the entity. Common concepts were then compared against cases from other entities. The results of the degree of agreement among different entities are presented in Chapter 4. This method was particularly helpful in identifying the determinants of BDA adoption across all the cases. Sub-themes were also identified using a cross-case analysis. For example, relative advantage was a common factor in the adoption of BDA which was frequently mentioned by the majority of informants across cases.

A cross-case analysis was also a seminal stage of data analysis where the emergent theories were identified through thematic analysis. These themes are extensively discussed and supported with evidence in Chapters 4 and 5.

3.8 Research Quality

One of the important criticisms directed against qualitative research is the lack of rigor and generalisability (Goffin, Raja, Claes, Szwejczewski, & Martinez, 2012; Seuring, 2008; Stuart et al., 2002). Näslund (2002) lists the anecdotal nature of qualitative research, which can render it biased, as an oft-cited criticism. In response to such criticisms, researchers have established several

criteria to evaluate the quality of qualitative research. There is a shift towards standardising qualitative research (Cassell, 2016; Symon, Cassell, & Johnson, 2016); however, there is still no consensus among researchers as to what criteria should be adopted. On the one hand, some argue that qualitative research requires its own evaluating criteria such as credibility, transferability, dependability, and confirmability (Guba & Lincoln, 1989). On the other hand, there are those who argue that conventional criteria such as construct validity, internal validity, external validity, and reliability are applicable to both quantitative and qualitative research (Ellram, 1996; Yin, 2014). In general, there is agreement that a detailed demonstration of rigor in research is highly significant (Flynn, 2008; Mentzer, 2008; Seuring, 2005). Since this research methodology is predominantly guided by Yin (2014), his validation criteria have been used in this research which will be demonstrated in this section.

Yin (2014) sets four different criteria to judge the quality of research designs. Each criterion and its application in this research are described below. A summary of this section is presented in Table 3.7.

- Construct Validity: This criterion refers to using "correct operational measures" (Yin, 2014; 87) for the phenomenon under study. To ensure this criterion is observed, the research relied on multiple data sources such as interviews' transcripts, site visit observations, field notes, and website documents (See Section 3.6). A summary of the key points of interviews and transcripts were also reviewed by key informants. This method created a chain of evidence (Stuart et al, 2002) that testifies to the validity of the research.
- Internal Validity: This criterion refers to 'causal relationships' between different concepts. A pattern matching technique was used during cross-case analysis to identify causal

relationships (See Section 3.7.3). This technique proved useful for identifying cause-and-effect of drug shortages and also the determinants of BDA adoption.

- External Validity: This criterion relates to the concept of 'generalisability' or the degree to which research findings can be generalised. It must be noted that qualitative research should strive for 'analytical generalisation' (Stuart et al, 2002; Yin, 2014) rather than statistical generalisability which applies to quantitative research. To this end, multiple case studies were selected based on 'replication logic' (See Section 3.5). Additionally, case study informants had similar job responsibilities with extensive knowledge of the pharmaceutical supply chain. The concept of 'polar types' was also followed in the case study selection phase (See Section 3.5.1).
- Reliability: This criterion refers to the repetition of the research procedures to produce the same results. An extensive database was created where information relating to case studies was stored. Field notes, interview transcripts, and documents were coded and imported to N-Vivo to establish the research database.

Table 3. 7 Criteria to address research quality
Source: Adapted from Yin (2014)

Criteria	Application in this Research
Construct Validity	• Multiple data sources • Transcripts reviewed by key informants (member checks) • A chain of evidence established
Internal Validity	• Cross-case analysis • Pattern matching
External Validity	• Replication logic in multiple case studies • Thematic analysis and thick description • Informants with similar job responsibilities and extensive knowledge of Australian pharmaceutical healthcare • Polar types
Reliability	1. Database created 2. Chain of evidence established in N-Vivo 3. Detailed description of procedures

The above criteria ensured that the rigor and quality of the research was maintained and strictly adhered to. It should be further added that Pratt (2009) advises qualitative researchers to use 'power quotes' and 'proof quotes' as further testimony to the rigor of their research and arguments. As demonstrated in this chapter, apart from a methodological approach to this research, the researcher has selected the most relevant 'power' and 'proof' quotes from informants which have been presented in Chapter 4.

3.9 Summary of Chapter

This chapter presented a detailed description of the research methodology utilised in this research. The research has adopted an interpretive paradigm founded on grounded theory. The multiple case study analysis of Australian pharmaceutical supply chain entities consists of five manufacturers, five wholesalers/distributors, and five hospital pharmacies, with a total of 20 interviews conducted.

A detailed description of the research design was outlined and the unit of analysis was also defined. Multiple data collection sources such as interviews' transcripts, site visit observations, and document analysis were employed to increase the validity of the research. The balanced distribution of entities also allowed a deep and holistic picture of the pharmaceutical supply chain activities of these entities to emerge. To analyse the data, the researcher implemented several methods such as N-Vivo coding, thematic analysis, and cross-case analysis to find patterns and contribute to the theory building. Finally, the findings were triangulated and a detailed description of the criteria applied to judge the quality of research was presented.

The next chapter will provide a detailed account of interview findings which have been presented based on the Research Questions.

Chapter 4

Research Findings

4.1 Introduction

This chapter presents the findings from interviews conducted to address the research questions and support and validate the proposed conceptual framework. To achieve this goal, two questions were devised around which further interview questions were designed (See Appendix A) to put forth to interviewees. The research questions are as follows:

- RQ_1: What are the determinants of BDA adoption in the Australian pharmaceutical supply chain?
- RQ_2: How does BDA improve decision-making across supply chain processes (SCOR processes: plan, source, make, deliver, and return) in the Australian pharmaceutical supply chain?

In addressing the research questions, the three major pharmaceutical entities comprising of manufacturers, wholesalers/distributors, and public hospital pharmacies were interviewed. Fifteen organisations were selected as case studies (five organisations in each entity) and 20 semi-structured interviews were conducted with five top managers in manufacturers, nine in wholesalers/distributors, and six in public hospital pharmacies in Victoria. Details of interviewees and their organisations' profile are presented in Chapter 3 (See Section 3.6.1). A thematic analysis and cross-case analysis were conducted on the responses to extract themes and insights relevant to

the research questions. The important quotes have been presented throughout this chapter to clarify and add context to the identified themes.

The remainder of this chapter is structured as follows:

- Section 4.2 – RQ_1: depicts a comprehensive picture of the determinants of BDA adoption which motivate or hinder BDA adoption.
- Section 4.3 – RQ_2: provides an insight into SCOR processes in pharmaceutical entities including manufacturers, wholesalers/distributors, and public hospital pharmacies. Following that, the main problems of this industry and the potential benefits of BDA for improving decisions across SCOR processes are analysed.

4.2 Determinants of Big Data Analytics Adoption

This section presents the analysis of interview responses to the following research question:

RQ_1: What are the determinants of BDA adoption in the Australian pharmaceutical supply chain?

The interviewees discussed the determining factors which motivate or hinder the adoption of BDA in their organisations. This study draws upon the technology-organisation-environment (TOE) framework to explore the determinants affecting the adoption of BDA. The TOE framework is classified into three contexts: technology, organisation, and environment. Table 4.1 presents the identified sub-themes in the interviews within each context and the number of informants who identified each one. Each of these sub-themes will be discussed in the following sections.

Table 4. 1 Determinants of BDA adoption

Entity	Number of Interviewees who Identified Sub-themes						
	Technology Context			Organisation Context		Environment Context	
	Relative Advantage	Compatibility	Data Quality	Top Management Support	Organisational Readiness	Government Policies and Regulations	Trading Partner Pressure
Manufacturers (n=5)	4	3	5	4	4	3	3
Wholesalers/ Distributors (n=9)	8	5	7	6	6	7	-
Hospital pharmacies (n=6)	4	-	5	3	4	5	-

n= Number of Interviewees

4.2.1 Technology Context

In this research the technological determinants indicated by informants comprise 1) relative advantage, 2) compatibility, and 3) data quality which are discussed below.

4.2.1.1 Relative Advantage

Relative advantage is defined as the degree to which new technology such as BDA can benefit an organisation (Lai et al., 2018). The benefits for organisations through the use of new technology can be both operational and strategic (Venkatesh & Bala, 2012). When organisations recognise the benefits of using BDA, they are more inclined to move towards the adoption of BDA to yield more benefits for their organisations (Chen et al., 2015). The cross-case analysis of interviews demonstrates that pharmaceutical entities have identified the potential benefits of BDA adoption for their organisations which can motivate them to adopt BDA.

Wholesalers identify that one advantage of BDA is that it contributes to better decision-making. Informed, evidence-based decisions can be made more quickly which will save costs. The current

data acquisition methods used through multiple platforms incur hidden costs on organisations in terms of labour cost and time. This challenge can be addressed through the adoption of BDA which will supply more precise information to the decision-makers. The positive influence of BDA adoption on decision-making is supported in the following comment:

> *If big data analytics is available to you, then you're making decisions a lot quicker and, essentially, you're saving time in people. You'd assume that you'd be saving money because there would be cost savings to be had wherever it is in the supply chain. I'd assume there is waste that we don't see due to the fact that people are having to manually obtain that data through multiple platforms or meetings or desk work, versus if the big data analytics was available to you. (Product and Purchasing Manager, Wholesaler/ Distributor J)*

In a similar vein, pharmacies identify the benefit of BDA in their supply chain processes especially in their planning and sourcing processes. Currently, procurement officers rely on historical data for conducting their supply chain operation; however, this method is not always an accurate indicator of consumption rates or patterns of drug use to assist in precise forecasts. BDA can enable predictive analytics which allows the involved entities to be proactive and make informed and precise projections about the future rather than the immediate short-term trends. This opportunity is voiced by the Director of Pharmacy at Hospital C:

> *I would expect big data analytics would guide things like your pattern of usage is changing or it's constant, or your re-order points; you're reordering too many times; it's inefficient because of the lead time, so you should reduce your reorder points or the amount of stock you hold. That would be very helpful because that'd help the procurement officers, the purchasing officers, when they're making decisions. ... So, there's nothing that actually guides them within our system, so it's all done by what they know which is not a reliable way of doing it necessarily. So, I can see all the way along the chain. (Director of Pharmacy, Hospital C)*

The following quote from Manufacturer O also highlights the advantage of BDA in using data more efficiently to have more accurate demand forecasts.

> *Everyone's looking at big data analytics and how to use that information better to plan, to forecast, all of those things; it is really important to get big data analytics and we are certainly looking at being more efficient and using that information in a better way. (Key Account Manager, Manufacturer O)*

Manufacturer N also states the advantage of having foresight enabled by BDA:

> *There's thousands and thousands of transaction processing that happens during the day right through our systems, and having good big data analytics capability really helps us understand where we are headed and what actions need to be taken. (Pharmacy Inventory and Systems Lead – ANZ, Manufacturer N)*

The cross-case analysis of interviews from all three entities points towards their recognition of the advantages that BDA can yield, mainly in planning and forecasting to make decisions that are more informed and save costs. These benefits can positively motivate organisations to adopt BDA.

4.2.1.2 Technology Compatibility

In this research, technology compatibility is considered as a motivating factor which increases the likelihood of BDA adoption for manufacturers and wholesalers. Technology compatibility is defined as "the degree to which the innovation is perceived as consistent with the existing values, past experiences, and needs of the potential adopter" (Rogers, 2003, p. 240). The business world is in an era of constant change where new technologies are introduced rapidly. Given the competitive nature of the market, organisations correspondingly review their operational efficiency and try to adjust and make the necessary changes to stay ahead of the game. As data-driven business culture gains more prominence, organisations try to upgrade their existing infrastructure to adapt themselves to new business models. The Manager of Data and Analytics Platforms at Wholesaler H believes that the adoption of BDA is compatible with their organisational needs and the adoption of BDA is their next stage:

> *It's an evolution. Now what we're trying to do is to bring that [BDA] in as a more mature environment. That's the next stage, and to bring these business analysts into one actual group. It was just a natural evolution and then making sure that we've got that silo of analytics can actually prosper with the right tools. … It's definitely the future of where we're going. (Manager of Data & Analytics Platforms, Wholesaler/Distributor H)*

In a similar vein to the above comment, Pharmacy Inventory and Systems Lead – ANZ at Manufacturer N also highlighted that they have perceived the need to adopt BDA as it aligns with their organisational needs to survive and prosper in their marketplace:

> *I guess more of it [intention to adopt BDA] is coming from within the organisation. (Pharmacy Inventory and Systems Lead – ANZ, Manufacturer N)*

It is evident that organisations cannot operate the way they traditionally did and the availability of enormous amounts of data mandates adopting new technologies such as BDA. Indeed, the transition towards BDA is an inevitable step which all organisations will transition towards not only to remain competitive, but to also reap the benefits. The cross-case analysis revealed that only manufacturers and wholesalers indicated technology compatibility as their determining factor to adopt BDA.

4.2.1.3 Data Quality

In the course of this research, the interviewees pointed out data quality as one of the significant facilitators which motivates them to adopt BDA. Data quality refers to the degree to which the data is accessible, accurate, complete, consistent, and timely for analytics (Hazen et al., 2014). Every day large volumes of both structured and unstructured data are created at an accelerating rate. Accordingly, businesses try to capture the relevant data to maximise their opportunities and benefits. This data can be classified into two categories: internal and external. Internal data refers to organisation-specific data which is generated from their everyday operations such as inventory

management data, financial transactions, customer orders, and sales. Internal data cannot alone be very sufficient in yielding competitive advantage or enhancing huge benefits. Internal data must be accompanied by external data which is defined as data that is collected from external organisations and resources. Examples can include government-owned data or supply chain partners' data that is willingly shared among other supply chain entities. Integrating both internal and external data is essential to ensure BDA capability.

- **Intra-organisational Data**

From an intra-organisational (internal data) perspective, interviewees stated that data is available, accurate, complete, reliable, and timely to make informed decisions. As an example, manufacturer N receives live data update on its inventory management system. At any given time, the manufacturer can accurately specify the production rate and consumption rate (selling to wholesalers or pharmacies). This system allows staff to ensure that adequate stock level is available in their organisations. From an intra-organisational perspective, this data is available and reliable to make informed decision**s**. The comment provided by the Pharmacy Inventory and Systems Lead at Manufacturer N exemplifies the accessibility of internal data in real-time:

> *When the production system dispatches goods out to the customer, at the end of the day there is an interfacing program which feed the data back into the decision support systems. So usually most of the data is available the next day so it gets loaded overnight so there is a twenty-four-hour delay. That data will hit the various decision support systems tomorrow morning. But for the inventory management side of things, we get our data as in live, so there is a refresh which happens every ten minutes between the production systems versus the inventory system and it makes sure that we have got the live data available to make sure that we don't run out of product. (Pharmacy Inventory and Systems Lead – ANZ, Manufacturer N)*

Similarly, the comment from Hospital C demonstrates the accessibility and accuracy of internal data:

> *I can tell what I've ordered and what I've consumed so that data is accurate, I know that. (Director of Pharmacy, Hospital C)*

The State Manager Hospitals in NSW at Wholesaler I also confirmed the accessibility and accuracy of their internal data:

> *We are able to rely on the data we have. In fact, I would say our data -- look there could always be little error in every data but I think our data sets are much better than other competitors' and even better than our customers'. (State Manager Hospitals in NSW, Wholesaler/ Distributor I)*

- **Inter-organisational Data: Manufacturers and wholesalers**

The pharmaceutical inter-organisational data (external data) in Australia is available, but only in a small capacity. For instance, some—though not all—manufacturers have access to some wholesalers' data through regular meetings or reports provided to them. External data can assist manufacturers to make adjustments to their demand forecasts as required. The following statement from the Head of Supply Chain at Manufacturer L testifies to their data accessibility:

> *With some of the wholesalers, we have monthly meetings to look at any trend that they're seeing directly on their side. So, they'll be sharing a lot of data with us -- basically all of the turns of inventory that are happening within their systems, we're seeing that and that's being shared, so we're able to adapt. (Head of Supply Chain, Manufacturer L)*

- **Manufacturers and Hospitals**

Data sharing among pharmaceutical entities is fragmented. For instance, hospital pharmacies' data is not shared with manufacturers which can assist them in their planning process. Indeed, there is

a lack of connection between supply chain partners in their data sharing. This issue is highlighted in the following comment from the Customer Service & Logistics Lead at Manufacturer M:

> *We've got wholesalers and they sell out to pharmacies. It would be really interesting for us to know how much stock on hand is at the pharmacies, because if they're running low ahead of projection -- well the data's there, it's all held on a computer. They know how much stock they've got, but they don't share that with us. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)*

As mentioned above, manufacturers do not have direct access to hospital pharmacies' data. To address this issue, a solution has already been implemented in Australia. There are independent data warehousing companies which have access to pharmacies' data, enabling pharmaceutical manufacturers to purchase it. For instance, Information Medical Statistics (IMS, currently rebranded to IQVIA) sells pharmacies' data to manufacturers. It should be noted that not all hospital pharmacies are registered to provide their data to IMS; therefore, hospital pharmacies data is not completely accessible to manufacturers. This dynamic is outlined in the following comment from the Head of Supply Chain at Manufacturer L:

> *In terms of the data we're accessing, so we're constantly getting feeds of IMS data to show what activity is happening within the marketplace which also gives us some insight into any molecules [components of drugs] that we are in competition with if there's any shortage of that sort of products or whether we're seeing any uplift in any of those products. (Head of Supply Chain, Manufacturer L)*

However, as mentioned earlier, not all hospital pharmacies are connected to these data warehousing companies. Besides, these companies do not provide real-time data to manufactures, leaving them with out-of-date data. Customer Service & Logistics Lead at Manufacturer M explains the efficiency of such data companies:

> *Nostradata and IMS, they warehouse data. That will give you the data for pharmacy sales, and only for the pharmacies that sign up to their data service. The other one does how*

many scripts have been written by healthcare professionals. The problem with this is that data is three months old by the time we get it; we get January's data in April; we get February's data in May. It's too late. We're in the digital world; it is 2019 -- I should be able to get that today. Why does it take three months to roll it up? So, our sales guys who are doing the forecasting that's what they look at trends in pharmacy sales and doctors writing scripts, but their data's three months old. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)

- **Manufacturers/Wholesalers and Hospitals through HPV**

Another important source of data is HPV which tenders for generic drug contracts on behalf of hospital pharmacies in Victoria (See Section 2.7.1). HPV provides wholesalers and manufacturers with a demand forecast about the required drugs for the hospitals. HPV's annual demand forecasts form an indispensable part of the wholesalers and manufacturers' external data source for their planning, sourcing, production, and distribution processes. This is evident in the following statement from the State Manager at Wholesaler/Distributor F:

So, we rely heavily on HPV for usage data, so they give us twelve-month usage data on their procurement contracts. So, any procurement contract that they manage whether it be pharmaceutical, wound care, medical consumables, they provide the manufacturer or the distributor a projected usage and we populate that into our system and then our system breaks it down onto a daily basis. (State Manager in VIC & TAS, Wholesaler/ Distributor F)

However, as the Hospital Account Manager at Wholesaler H claims, data provided by HPV is not highly accurate for wholesalers and manufacturers to completely rely on:

More accurate data would help significantly, there's no doubt about that, because whether it's from individual customers or HPV the data is quite inaccurate and they could understate or overstate. … So, anything that improves the accuracy of the data would help. (Hospital Account Manager, Wholesaler/ Distributor H)

In other words, HPV creates a bridge in terms of external data between hospital pharmacies and wholesalers/manufacturers in Victoria. As demonstrated in the above comments from interviewees, both internal and external data are available which forms an essential component of their supply chain processes. However, it should be noted that internal data (intra-organisational) is more accessible and accurate than external data (inter-organisational).

- **Among Manufacturers**

Although manufacturers try to analyse their available data and create accurate demand forecasts, they are not aware of the wider market and what other manufacturers are doing in this regard since data is not shared. This lack of shared data can disrupt demand forecasts and cause unanticipated issues such as drug shortages. The Customer Service & Logistics Lead at Manufacturer M identifies this impediment in the following comment:

> *So, if Manufacturer X goes out of stock, I wouldn't know, and all of a sudden, my demand has doubled and that's why we run out of stocks. So, this is where you try to talk with wholesalers. The wholesalers won't talk to you about other manufacturers' products. It's like a professional courtesy; they won't tell you what's happening, or what other manufacturers are doing. So really you only know what you know, you don't know what else is happening. It's very hard, we're not very good at finding out what's happening out in the marketplace. So, that's why I wanted to describe … our demand/supply is quite complicated; it's very IT intensive, and it works pretty well, but no matter how good that is, it's still only looking at Manufacturer M. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)*

- **Among Hospitals**

Even though hospital pharmacies possess useful data, they are reluctant to share it with their counterparts. Lack of data-sharing partly emanates from the fear of increased competition and the resultant reduced profits. Despite abundant evidence that data-sharing contributes to profit growth,

public hospitals keep their data isolated from one another, thus, creating siloed data or a repository of raw and unstructured data that remains unanalysed and unable to yield economic benefits. Although some hospital pharmacies utilise the data, the scale is not sufficiently comprehensive to lead to accurate decisions. The comment by the Chief Pharmacist at Hospital A gives evidence to this phenomenon:

> *We don't get granular-level access of what other hospitals are doing. It'd be nice to have, but I guess everyone's probably a little bit precious about their data. … But at the same time, there's plenty of evidence out in the literature to say that collecting this data and aggregating it and putting it out in the public space actually has many economic benefits -- different companies can analyse it, the ideas and concepts can come from it rather than hiding it all. So, health suffers from the opposite to big data which is siloed data. So, there's probably big data around, but a lot of it is siloed, disconnected, not used and analysed. So, people are collecting data, very few people actually use the data for something meaningful, and even if they do run a report off it, there's probably even less data used for turning data into information and then into decision-making. (Chief Pharmacist, Hospital A)*

One of the causes of the lack of data-sharing among hospitals is associated with the nature of the Australian public hospitals which is government-funded. Access to data can be interpreted as a performance indicator of hospitals and therefore, attract more or even less funding from the government, depending on the level of data accessibility. It also happens at an intra-organisational level where one department does not share data with other departments within the same organisation. The Chief Pharmacist at Hospital A voiced the following observation regarding the lack of data-sharing:

> *Well at a macro level, the silos are government resistance to probably put out and share data. At a hospital or at an inter-hospital level, hospitals are probably a bit reserved about sharing data with other hospitals. I think because everything's performance-driven these days and so I'll only tell you what I have to tell you; but if I found out or another hospital found out that we're doing better, then they might get more funding than us. (Chief Pharmacist, Hospital A)*

The cross-case analysis reveals that Australian pharmaceutical entities suffer from a lack of data-sharing. It is evident that if the degree of data quality increases, organisations will have a stronger incentive to adopt BDA. In other words, when data is more accessible, accurate, and complete, organisations are more confident that they can adopt and utilise BDA successfully.

4.2.2 Organisation Context

In this research, the organisational determinants indicated by informants comprise 1) top management support and 2) organisational readiness which are discussed below.

4.2.2.1 Top Management Support

Top management support refers to the degree to which top managers understand and support the adoption of new technology (Ragu-Nathan et al., 2004). An increasing level of top management support can increase the likelihood of BDA adoption in an organisation (Lai et al., 2018). BDA is a relatively recent phenomenon that businesses are beginning to acquaint themselves with and it requires a substantial level of investment in establishing both the technology and fostering analytics skills. Indeed, the nature of BDA differs from traditional business investments which have a quick return of investment. Organisations need to consider that BDA yields might take time to come to fruition; hence, this requires a significant amount of time and devotion in terms of investment. Given the sizeable level of required investment, top management support is crucial in this regard as acknowledged by the Head of Supply Chain at Manufacturer L:

> *I think managers in general understand the efficiencies that could be gained for their own businesses for some significant upfront investment [in BDA adoption] that would generate long-term automation and savings. (Head of Supply Chain, Manufacturer L)*

In a similar vein, Wholesaler I, the most automated Wholesaler in Australia, noted that managers at Wholesaler I have recognised the need for investment in BDA and they are considering investing in this area in the near future as indicated by the following comment from the State Manager at Wholesaler/Distributor I:

> *There are some debates happening from spending $10 million. … And I think in the next two to three years' time, like all other major companies, we will have to make a call on what process do we need to invest in for that [BDA adoption]. (State Manager Hospitals in NSW, Wholesaler/Distributor I)*

However, the Chief Pharmacist at Hospital A stated that since the government funds Australian public hospitals, improved service quality takes precedence over any financial gains. Hence, investment in new technologies such as BDA has not been deemed a high priority for hospital top managers. Therefore, despite the fact that pharmacy directors are cognizant of the benefits of BDA for their supply chain operations, they do not have the support of hospital top managers or Australian governments to adopt BDA:

> *Now in Australia we're probably not as sort of progressed or advanced in that space and that's for a couple of reasons. One is that, particularly in the public system, the government is paying. And so, although they'd like to have that granular level of data, they're not necessarily willing to pay extra money at this point anyway to get that. … So, we're talking about AU$25 million to pay for drugs in this hospital. … But if I say I need four million dollars' worth of equipment to do that [adoption of BDA], the government might say oh that's OK, we won't worry about it. … It [public health system] is actually not cost-driven; it's more service and quality-driven. (Chief Pharmacist, Hospital A)*

Manufacturers also highlighted the significance of top management support to make investments—not only in new tools and technologies but also in sourcing data. Manufacturers need to purchase wholesalers' and hospitals' data from data warehousing companies which usually comes at an enormous cost. They have to pay for their required data since there is no direct, or

adequate, data-sharing protocol among pharmaceutical entities. Therefore, to facilitate BDA adoption, manufacturers' top managers must provide adequate funding to enable their organisations to access the big data that exists along the pharmaceutical supply chain. The Customer Service and Logistics Lead at Manufacturer M cited the necessity of investments on sourcing the required data, apart from the associated technologies:

> *We have to buy data. So you buy data from Nostradata and IMS; they don't give it away for free. Wholesalers, you have to buy the data, they don't give it to you for free, so we pay many tens of thousands of dollars. For all wholesalers, we probably spend four or five hundred thousand dollars buying their data. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)*

Investment in BDA adoption is not limited to IT infrastructure (software and hardware) but it is certainly aligned with leveraging analytics competence to pave the way for the adoption of BDA. Data scientists/analytics professionals are not the same as IT professionals; they have fundamentally different skills. Accordingly, pharmaceutical organisations prefer to hire qualified candidates and/or train their current staff to develop their internal capabilities to achieve the required technical skills. The Customer Service and Logistics Lead at Manufacturer M poignantly emphasises the importance of top management support on development and training programs for their current employees:

> *I suppose within business intelligence team they've already had that training [on the use of BDA]. ... Our company is supportive of that. ... In fact, our CEO in UK, it's one of her top priorities. She's all the time saying you have to develop your people. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)*

The cross-case analysis reveals that top management support paves the way for the adoption of BDA. Manufacturers receive more support from their top managers for initial investment in developing organisational IT infrastructure, recruiting professional data analysts, establishing

training programs for upgrading current staff capabilities, and purchasing data for analysis. Wholesalers are in the middle, but hospital pharmacies are not supported by hospital managers or the Australian governments since the essence of public hospitals is service-oriented rather than cost-oriented.

4.2.2.2 Organisational Readiness

Organisational readiness is defined as "the availability of the necessary organisational resources for using BDA" (Chen et al., 2015, p. 18). If the level of organisational readiness is higher, the intention of organisations to adopt BDA will be stronger. These resources comprise both robust IT infrastructure and professional employees with analytics skills (Agrawal, 2015).

- **Robust IT Infrastructure**

A vital requirement for the effective adoption and implementation of BDA is organisational IT infrastructure. As a huge volume of data from various sources is produced daily, robust IT capabilities are required to manage and process this ever-growing data. Currently, a large proportion of the available data remains unstructured, which is yet to be analysed, to produce meaningful insights for organisations' decisions. Organisations have become more aware of upgrading their IT infrastructure to effectively capture, store, and analyse big data. There are different types of software such as Hadoop (a software that stores and processes large volumes of data in clustered systems that is particularly well-suited to big data applications) or NoSQL database (a database which is suitable for processing and handling large and unstructured volumes of data) that are used for BDA. The software and databases are used for capturing, storing, processing, and analysing data to glean insights from different sources and turn them into

guidelines for decision-makers. Although Australian pharmaceutical entities are not yet highly advanced in technological infrastructure/capability, they all rely on varying levels of technology to guide their decision-makers based on their organisational needs. Figure 4.1 represents the technological maturity of pharmaceutical entities across the supply chain. As is evident, entities are more technologically mature as they move upstream in the supply chain.

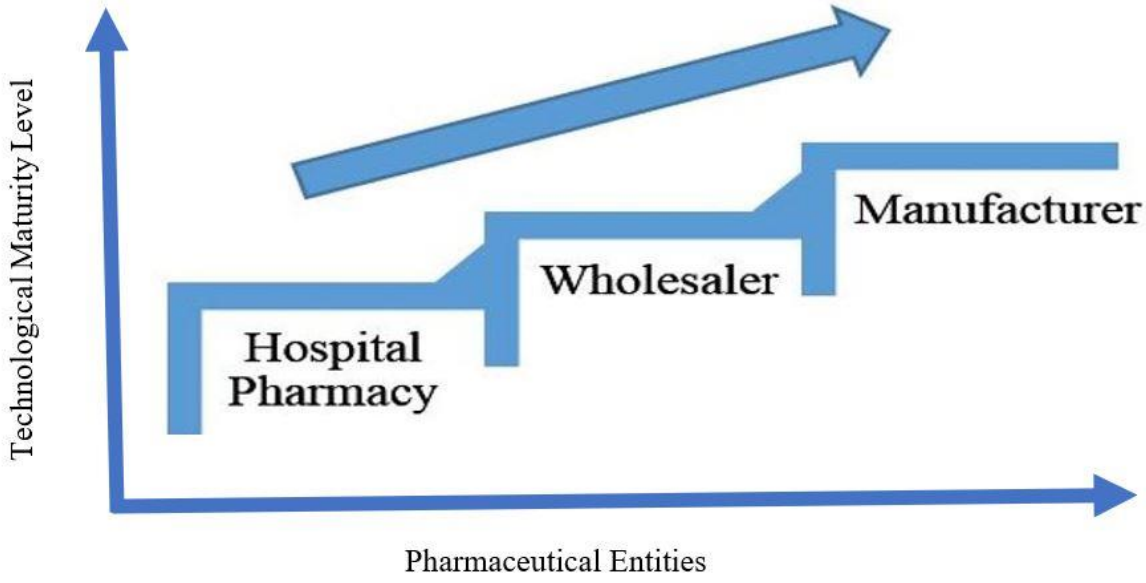

Figure 4. 1 Technological maturity level in Australian pharmaceutical entities

- **Manufacturers**

As Figure 4.1 illustrates, manufacturers have the most advanced data analytics capabilities and infrastructure among Australian pharmaceutical entities. They generally have different systems to process their data in various departments within their organisations. The following comment from the Head of Supply Chain at Manufacturer L points to the IT infrastructure in their organisation

where they use a variety of software and databases in different departments to effectively capture data:

> *We use a combination of the internal system. So, we use salesforce.com, so the commercial folks when they're interacting with healthcare professionals, they'll use Salesforce. There's other areas of the business that uses Veeva System. There's obviously the Systems, Applications, and Products (SAP) database and everything that sits within that. The finance team are feeding data into Tableau, so they're the internal systems that we're using to gather data. (Head of Supply Chain, Manufacturer L)*

Similarly, the Pharmacy Inventory and Systems Lead at Manufacturer N confirmed their organisational data analytics infrastructure. Their organisation relies on different technologies to analyse their data and produce different reports which serve as a basis for their decision-making. IT infrastructure is vividly described by the Pharmacy Inventory and Systems Lead at Manufacturer N:

> *So, because this is such a huge organisation, we've got various decision support tools which exist within the system. Our system is J.D. Edwards, where all the transaction processing happens. But then we've got IBM COGNOS BI as one of our tools for where all the data is stored. So, we've got various data warehouses anyway, but then it feeds off into various systems. (Pharmacy Inventory and Systems Lead – ANZ, Manufacturer N)*

- **Wholesalers/Distributors**

The robustness of technological infrastructure of pharmaceutical entities declines as it moves downstream. Wholesalers have their own IT departments and tools developed internally which produce reports regularly to ensure their inventory is efficient and responsive to market needs. The IT infrastructure of wholesalers is well captured in the comment from the State Manager Hospitals at Wholesaler/ Distributor I:

> *We have our own IT department that manages the maintenance of our tools and infrastructure, so we can actually access the data on a regular basis. From within the data, we have some already prepared templates that is produced so that we can actually check the temperature of the business. So, there are certain reports that come out on a daily basis and senior execs to junior people they actually watch it to see things like our service levels, our field rates etcetera, how we are going against our procurement versus what we are selling. So, there are some tools there which have been created internally and we use them on a regular basis. (State Manager Hospitals in NSW, Wholesaler/ Distributor I)*

However, wholesalers' level of technological maturity varies from fully-automated systems to semi or low levels of automation. Customer Service & Logistics Lead - Intercontinental Supply Chain at Manufacturer M stated the discrepancy in the level of IT infrastructure among wholesalers, ranging from outstanding to abysmal, which affects their inter-organisational collaboration:

> *It depends on the wholesaler. So, a big part of my job is to largely deal with the four biggest wholesalers which are Symbion, Sigma, API and CH2. And they're all at different levels of maturity. So, Wholesalers X and Y have terrific IT and I can log in and I can get data from them and we collaborate quite maturely as far as data information shares. Whereas other wholesalers they can barely run their own computer systems let alone share anything. So, it's at different levels of maturity. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)*

In a similar vein, the Head of Supply Chain of Manufacturer L echoes the same sentiment about the level of wholesalers' technological maturity in managing and sharing their data:

> *Say Wholesalers X and Y as an example. We actually have access to their portal. So, we can pool that data at any stage that we'd like, but we also get a formal report on a monthly basis. So, Wholesalers X and Y are the most advanced of the wholesalers when it comes to -- I guess how relevant their data is and the way in which they share it, whereas the other wholesalers are a little bit behind in that space. (Head of Supply Chain, Manufacturer L)*

- **Hospital Pharmacies**

As is evident in Figure 4.1 (see above), the technological potency of wholesalers/distributors is visibly inferior to that of the manufacturers. The level of technological maturity down the pharmaceutical supply chain at the hospital pharmacy level is very simple, relying on simple Microsoft tools as indicated in the following comment from the Chief Pharmacist at Hospital A:

> *Well our ordering would be done in our pharmacy system. Most of the decision-making is probably Excel. So, Microsoft Excel and Pivot tables probably is where a lot of the work is done in reality. Once I've taken the data and sort of done end of month reporting and stuff -- I do tend to push it into Power BI. (Chief Pharmacist, Hospital A)*

Similarly, the Head of Supply Chain of Manufacturer L explicates the insufficient IT infrastructure in public hospitals very vividly and expresses his frustration over the loss of opportunities. Indeed, the varying level of technological maturity among pharmaceutical entities hinders inter-organisational collaboration. This disparity in access to sufficient IT infrastructure and skilled human resources, especially in hospital pharmacies, has a profoundly negative impact on the entire pharmaceutical supply chain operations:

> *There's so much possibility with data in the supply chain, but the hospital pharmacies within that chain are not technologically enabled or sophisticated or funded in the public sense certainly to be able to take advantage of the data that's out there. (Head of Supply Chain, Manufacturer L)*

Indeed, the challenge of technological resources is more evident in public hospitals. In extreme cases, some public hospitals do not even efficiently employ rudimentary technology, which has been around for quite some time. The Head of Supply Chain at Manufacturer L vividly portrays the situation:

> *They [public hospitals] are extremely behind, some of them are using manual registers to ascertain what patient's having, what product at what time. So, they're not even using a traditional bar code or a GTIN. So that's your worst-case scenario. But then you've got others, maybe more in the private sense, … that are fully enabled, scan their patient in, everything that goes to the patient's scanned and logged and information's flying back and forth between all of the stakeholders within the chain. … We deal with huge customers in Australia that aren't even on Electronic Data Interchange (EDI) ordering with us. So, we've literally got them at one end generating a purchase order and us at the other end keying it into a system and it is 2018 and EDI's been around for how long, twenty years. (Head of Supply Chain, Manufacturer L)*

The following comment also corroborates how robust IT infrastructure can improve the pharmaceutical supply chain:

> *I often dream about a world where we've got hospitals using products that are electronically flown back through to the wholesalers. Those orders are then being consolidated in a sophisticated system which are then flown back, via EDI, through to manufacturers and orders are being replenished without any human reconciliation or any need for any of that. There's absolutely no reason why that couldn't happen, all -- the technology's there, been there for some time. (Head of Supply Chain, Manufacturer L)*

- **Skilled Human Resources**

Adopting BDA cannot be realised without skilled human resources. BDA is not only about technology, but is also heavily reliant on human resources to be effectively mobilised. Therefore, a prominent aspect of BDA adoption is an organisation's human resources comprising of staff with business acumen, skills in communication, problem-solving, leadership, and creativity (Gupta & George, 2016). The technical side of BDA requires skills in coding and programming, statistical analysis, data extraction, and machine learning (Gupta & George, 2016). The current business climate is constantly evolving and new technologies and tools are put in place to respond to new developments. Therefore, human resources also need to evolve accordingly—hence, the critical role of skills development. In fact, there is a positive correlation between the internal skills

development and adoption of new technologies. The importance of training and developing staff in the rapidly changing business world is aptly described by Pharmacy Inventory and Systems Lead at Manufacturer N:

> *There is a specific functional area which manages the analytics and the systems in terms of data warehousing and report generation, and that team actually does the job. They constantly have sessions for training whenever they upgrade, something for all the people who have got access to write reports or even use the reports. … And they would make sure that the end users are properly trained to use such systems to get data that they're usually looking at. So, the answer to the question is definitely there is a lot of resources put aside to manage that and time as well to make sure that people are properly trained. (Pharmacy Inventory and Systems Lead – ANZ, Manufacturer N)*

The interviewees almost unanimously agreed that the adoption of BDA relies on organisations' human resources with analytics capability. Therefore, fostering internal capabilities can prove essential in embracing BDA adoption. The significance of appropriately skilled human resources who are proficient in both supply chain domain and data analytics was accentuated by the manufacturers. When it comes to human resources, it is often challenging to cover both these areas of expertise which can be immensely helpful to organisations as indicated by the Head of Supply Chain at Manufacturer L:

> *When I think back previously to Manufacturer X, within the supply chain I had an IT guy that was a supply chain IT guy specific. All of this work was his bread and butter. In Manufacturer L, I don't have a dedicated resource that looks after that type of thing, so I don't even have an expert within my own team. And I think that issue is replicated throughout many businesses whether they be hospitals, compounders, wholesalers, and manufacturers. (Head of Supply Chain, Manufacturer L)*

In a similar vein, the adoption of BDA in hospital pharmacies is hampered by the shortage of sufficiently skilled analytics staff with domain knowledge (healthcare, supply chain) to be able to

both understand what their organisations require and help them make informed decisions. The Director of Pharmacy at Hospital C explicates this challenge:

> *There's no data scientists. There's some analysts but you actually need data scientists and you actually need clinicians who actually know the clinical question and you need the people who actually have the skills for extraction. (Director of Pharmacy, Hospital C)*

The following comment similarly highlights the role of skills in BDA adoption:

> *If you go to the public section of hospitals, the biggest barrier is resource in terms of head count and money, and also dedicated people that can work on these sort of projects and the technical experts. (Head of Supply Chain, Manufacturer L)*

The prospect of having skilled data analytics workforce in pharmaceutical organisations is conceivable. Given the significance of BDA adoption in today's economy, many organisations are shifting their focus in order to gain the maximum yield. It is assumed that in the near future, pharmaceutical entities will be considering the recruitment of data analytics professionals/data scientists who are expected to have an acceptable level of domain knowledge. This is a realistic possibility which will eventually materialise. The comment by Director of Pharmacy at Hospital C reverberates this prospect:

> *I think in ten years' time, we'll be in a better position than we are now, because big data's been talked about; Access to our data is now becoming a little bit more realistic for a whole lot of reasons, and the inter-operability and integration is becoming a bit better. For example, there's a doctor who works partly for me who is a data scientist. His original training was data science and then he went off and did medicine, which is a fantastic combination because he can deal with the clinical and the technical side of things. So, he's got access to some of our data and for the first time we're starting to ask questions of our data. But that's quite unusual at this time, but that will change. (Director of Pharmacy, Hospital C)*

The cross-case analysis reveals that pharmaceutical entities possess varying levels of organisational resources. The larger manufacturing organisations generally have a robust IT

infrastructure to collate data from various resources. They also have skilled employees to perform data analysis. However, moving down the supply chain stream, the level of rigour, in terms of organisational resources, deteriorates sharply. Although wholesalers have their own IT department, their level of technological maturity differs from fully-automated systems to low levels of automation. Also, hospital pharmacies have neither a robust IT infrastructure, nor skilled human resources. Despite the fact that Australian pharmaceutical entities are at different levels of readiness, they confirmed that increased levels of organisational resources can increase their intention to adopt BDA.

4.2.3 Environment Context

In this research environmental determinants indicated by informants include 1) government policies and regulations and 2) trading partner pressure which are discussed below.

4.2.3.1 Government Policies and Regulations

Government policies and regulations are regarded as an environmental factor which can facilitate or inhibit the adoption of new technology such as BDA (Lai et al., 2018). The following comment from the Pharmacy Inventory and Systems Lead at Manufacturer N confirms the influence of the government's regulations on the adoption of new technologies.

> *We are operating in a very highly regulated environment because we are a pharma, and sometimes there might be some requests from regulatory affairs or somewhere like TGA that might need specific things, so we would look at upgrading or providing such sort of information through and upgrade to the system. (Pharmacy Inventory and Systems Lead – ANZ, Manufacturer N)*

Although pharmaceutical entities are currently willing to benefit from the opportunities provided by BDA adoption, they are hindered by Australian policies and regulations. Unlike other industries, the pharmaceutical healthcare industry is heavily regulated due to its unique nature. The current regulations fail to support the adoption of BDA. The Key Account Manager at Manufacturer O made the following comment to this effect:

> *There's a lot of compliance and regulations within our industry which makes it difficult. Probably, we are slower to adopt these types of technologies into our business and use them in the best way, say, a different type of a company like Fast-Moving Consumer Goods, if you're making food instead of medication. … Using BDA can really form and guide your decisions. But it's much harder in the space of pharmaceuticals because you have very rigid regulations around how to engage with the customer, how to engage with the patient, how to engage with the government. (Key Account Manager, Manufacturer O)*

The Key Account Manager at Manufacturer O also indicates that collaboration between pharmaceutical entities and government bodies is the key solution to effective access and utilisation of data that exists along the supply chain to facilitate the path toward BDA adoption.

> *They [government policies and regulations] dictate how you collect the data; how you gather the information; how you use it. And because of the compliance it's very difficult to get a lot of the information. The information that we might need might be difficult in the setting of pharmaceuticals, privacy, patients, medication, all of that. So, I think better collaboration with the Federal and the State bodies would definitely be ideal. And that's what we do, we have a team now that liaises with and works with the government on those various issues, not just with relation to BDA but for better communication so that we can have a better flow of information, better access and this all links in together at the end of the day. (Key Account Manager, Manufacturer O)*

As highlighted above, although governments can request pharmaceutical entities to adopt new technologies to upgrade themselves, they currently pose difficulties in access to data and the opportunity to adopt BDA.

4.2.3.2 Trading Partner Pressure

Trading partner pressure refers to the pressure from supply chain entities upstream or downstream which impacts an organisation in terms of adopting new technology such as BDA (Hsu et al., 2014). Based upon the TOE framework, trading partner pressure can positively motivate organisations to adopt BDA to maintain their cooperation with their supply chain partners. The Customer Service and Logistics Lead at Manufacturer M identifies customers' expectations as the main form of pressure that enables them to upgrade their technology.

> *The government is now looking at serialisation. They want to be able to track every single box from the time it leaves the site, the manufacturing site till the time it goes to a patient. ... It's gonna create a huge amount of data. So, we're looking at how we fit into that system. So there's always new IT systems coming along. Our customers want EDI, electronic data interchange, on time. So it used to be that they just wanted to be able to order online. Now they want to be able to order online and get an order acknowledgement, ... to know when the product's coming ... when it's left the door ... when they receive it ... and then we should know where it all is. So that all generates data and that can all be queried and it can all be analysed through new IT systems, so there's a lot of data out there. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)*

In a similar vein, Pharmacy Inventory and Systems Lead – ANZ at Manufacturer N mentioned that both upstream and downstream pressure can motivate them to adopt the new technology to satisfy their partners' expectations.

> *It [intention to adopt BDA] could come from our customers and suppliers sometimes. (Pharmacy Inventory and Systems Lead – ANZ, Manufacturer N)*

The analysis reveals that the pressure from trading partners, both upstream and downstream, can encourage manufacturers to adopt BDA to enable them to continue their cooperation with their partners.

4.3 Potential Impact of Big Data Analytics Adoption on Decisions across SCOR Processes

This section presents the analysis of interview responses to the following research question:

RQ_2: How does BDA improve decision-making across supply chain processes (SCOR processes: plan, source, make, deliver, and return) in the Australian pharmaceutical supply chain?

Before investigating the impact of BDA on pharmaceutical supply chain operations, it is essential to analyse the current practices in each SCOR process and identify the problems that pharmaceutical entities encounter. Therefore, this question serves a threefold purpose:

- Exploring how different stakeholders in this study including hospital pharmacies, wholesalers/distributors, and manufacturers are conducting their supply chain processes (SCOR processes: plan, source, make, deliver, and return);
- Outlining the difficulties they encounter;
- Determining whether the adoption of BDA can improve their decisions across SCOR processes.

Figure 4.2 visualises the ideal practices of pharmaceutical entities in the context of SCOR processes.

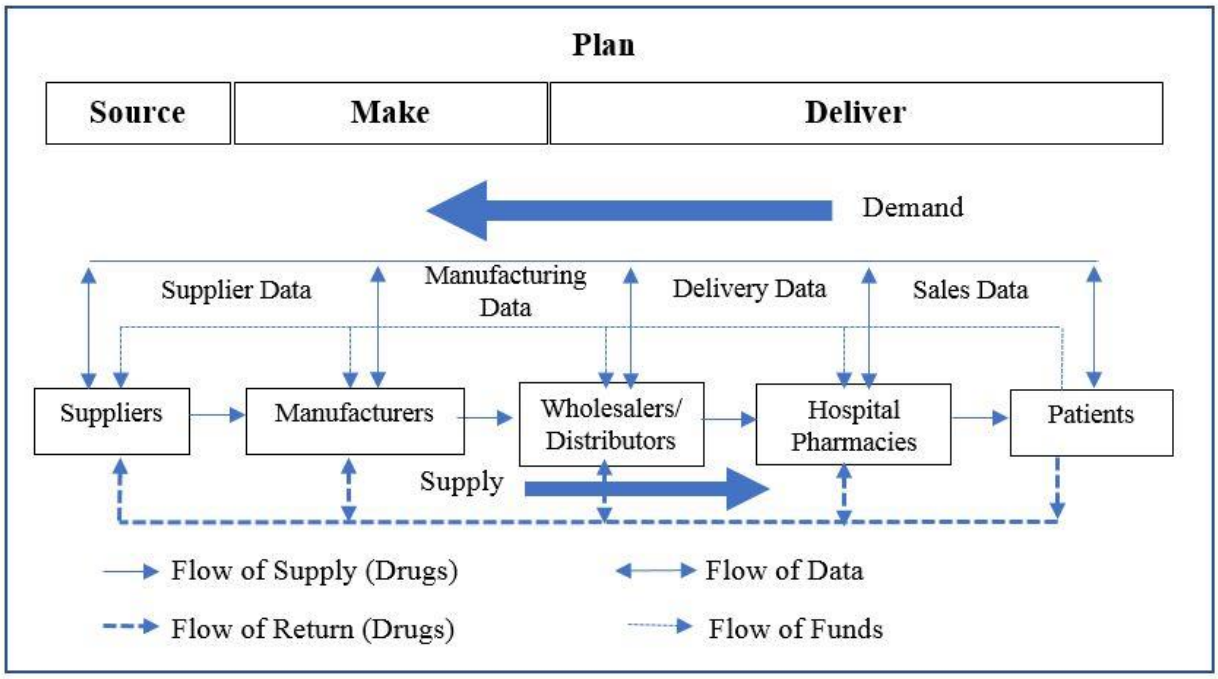

Figure 4. 2 Pharmaceutical supply chain structure in the context of the SCOR model

Source: Adapted from Biswas and Sen (2016)

Each process in the context of the Australian pharmaceutical supply chain is discussed separately below. Informants' responses to and perspectives on the question raised varied depending on their position in the supply chain.

4.3.1 Plan

- **Hospital Pharmacies**

It should be noted that all the hospitals in this study are large metropolitan public hospitals located in Melbourne. Public hospitals receive a certain amount of funding from the state government each year; therefore, directors of pharmacies at hospitals carefully plan their supply. They analyse their historical data to estimate the number of patients who refer to their hospitals during the year and

the kinds of drugs they would require. Another important criterion for planning is government policies which change from time to time. As a result, pharmacy directors must comply with and consider new policies in their planning. The following comment from the Director of Pharmacy at Hospital C captures the planning process:

> *… So one of the things I do is to reach out to those units to say OK what they are planning to do, how many patients are they thinking of treating this year … they'll be budgeting as well. And that then helps me to determine what drugs I'm likely to [need] … because we're normally talking about quite expensive therapies in that group. … Obviously from my perspective, I'm looking at historical data too, so I can see what we've used last year, what the growth pattern was the year before and to see whether that's going to continue on. So, I have those sorts of elements that I can use to actually work out my plan. The other thing that I can do is to look at what's likely to influence me so what is happening in government; are there some government changes that are going to occur … So, you can get a sense of what I may have to plan around. And of course, obviously, the thing that I can't plan for is when there are stock outages which is quite common. (Director of pharmacy, Hospital C)*

- **Wholesalers/Distributors**

As for the planning process, wholesalers have their inventory management systems. Therefore, they create daily transaction reports regarding the amount of available stock and daily sales of each drug and keep these reports for several months. These reports enable wholesalers to monitor the usage trend of each drug and adjust their demand forecasts accordingly. In Victoria, wholesalers also follow the projected usage of generic drugs on the tenders provided by HPV for their predicted forecasts. Wholesalers need precise forecasts; otherwise, they might either end up with surplus stock or fail to meet pharmacies' needs. The following comment clearly encapsulates the planning stage of wholesalers/distributors:

> *… So that's our inventory management system and it does have a website. So daily it is adjusting forecasts based on history and any knowledge of forecasting or projected usage that the hospitals have given us; we update that all the time …. So we have a daily report*

that shows transactions and we keep that for three months. So we can see the trend, if there's a trend in the uptake of a product or if it's decreasing in sales. So we're not caught with excess stock and it goes out of date and then you have to write it off. The actual Distribution Centre just has the quantity of what's been taken away from each product. So we manage it daily; there's algorithms in the background of this report that identifies any potential issues. If there's out of stocks or excess stock, and we get fed this information back to us to either follow up with the hospital because they're not buying it when they said they would basically. It's mainly HPV driven so we go back to HPV mainly. (State Manager in VIC & TAS, Wholesaler/Distributer F)

- **Manufacturer**

Manufacturers use different forecasting software to predict their potential demands. They rely heavily on their historical data on past sales and then review and adjust the data regularly to ensure they have relatively accurate forecasts. They remain fully alert to monitor the demand changes which might occur on account of an increase in global demand due to a widespread epidemic outbreak or a competitor's failure to supply the market. Manufacturers rely on professionals who are completely familiar with their market to be able to make precise adjustments. They also consider governments' new policies such as the PBS for the planning phase (See Section 2.7.1). The following comment from the Head of Supply Chain at Manufacturer L outlines the planning process and its accompanying challenges:

So globally we run SAP software and basically our forecast is put in – well, we put in a three-year forecast into a system and that's a rolling forecast. And each month my demand manager looks at the forecast and makes any adjustments and then locks down.... There could be global demand that's changed; the US is probably the best example. If demand increases in the US, it might be at the sacrifice of the other affiliates not getting as much stock that they might have forecast. Or it might be that there's a smaller market that's had an issue, a competitor's gone out of stock and they need to steal some stock from what demand was already in the system. So there's quite a few dynamics that change things, but in terms of the forecast it's really in for three years but it's reviewed every month. So the demand manager will sit with each of our brand managers through the month and just understand if there's anything changing; is there an upcoming PBS listing that we need to

> *be prepared for; is a competitor forecast to be out of stock, … and do we need to start thinking about getting extra inventory in now to overcome that. So whilst it's set in the systems, there's also the ability to revisit that on a monthly basis and bring it up or down depending on what dynamics there are, or as I said it could also be forced up or down by other dynamics outside of our control. (Head of Supply Chain, Manufacturer L)*

As reflected in the above comment, the manufacturers' planning process is a dynamic and complex one which can be affected by many unanticipated events, hence requiring high levels of flexibility, alertness, and responsiveness.

It seems that the fluctuation in demand does not apply to every pharmaceutical product. The use of some products remains reasonably stable each year. Therefore, it is easy for manufacturers to predict the demand and plan to manufacture them. However, forecasting the demand for other medicines depends on other factors which may vary from time to time. Customer Service and Logistics Lead's observation at Manufacturer M testifies to this fact:

> *Thankfully, for a lot of pharmaceutical products … it's very stable. So, say for Ventolin, we sell the same amount of Ventolin every single month pretty much, but then there's other products. So a lot of respiratory products are dependent on the season, hay fever, flu, whether it's hot or cold or it's humid, when there's bushfires, all these different things. Sometimes though, you will get them like that, and we will forecast based on our statistical models and we will put in those types of curves to try to match. But it's only in history. So as long as the history's good, our forecast is good. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)*

The cross-case analysis reveals that pharmaceutical manufacturers heavily rely on their historical data for demand forecasting. As discussed in Section 4.2.1.3, collaboration and data sharing are not sufficient among pharmaceutical entities that force manufacturers to create their forecast demands based on data that is not accurate, complete, and timely. This issue results in drug shortages in some cases. The following section discusses the causes and consequences of drug

shortages in the pharmaceutical supply chain and the potential positive impacts of BDA on mitigating this challenge.

- **Drug Shortages**

One of the main problems that was unanimously pointed out by all the informants in this research was the issue of drug shortages which affects all pharmaceutical entities. All the interviewees identified drug shortages, including both short-term and long-term shortages, as the number one problem they encounter. Therefore, in this section, this issue will be examined. The solutions pharmaceutical entities are implementing to tackle drug shortages will be outlined while the reasons for the problem will also be investigated. Additionally, the potential positive effects that BDA adoption can exert to address the issue will be analysed.

The comment provided by the Director of Pharmacy at Hospital C testifies to the gravity of drug shortages:

> *So probably every day we'd have about seventy or eighty drugs we can't get, or SKUs we can't get, and sometimes they're just for a few days in which case you just deal with it, but there's about twenty of them that are long-term and that has an impact; so we can't use that drug. We have to use something alternative, or we have to ration them. (Director of Pharmacy, Hospital C)*

In a similar vein, the State Manager at Wholesaler/Distributor F also confirmed the existence of drug shortages:

> *There's a lot of drug shortages at the moment. And on the HPV tender there's approximately a hundred and twenty currently … long-term stock-out. So, long-term we classify more than a month basically, or if they're in short supply. (State Manager in VIC & TAS, Wholesaler/ Distributer F)*

- **Current Solutions for Drug Shortages**

In response to drug shortages, hospitals resort to purchasing more drugs than they need to offset the effects of shortages or out-of-stock situations. Informants confirmed that these actions are taken to alleviate drug shortages but increase their costs through allocating staff to handle drug shortages and buying alternative drugs which are more expensive compared to subsidised ones. The comment provided by the Director of Pharmacy at Hospital B echoes these issues and challenges:

> *We have a significant issue around drug shortages across Victoria. We run what is essentially a whole person who manages our drug shortages, so it costs us just in human capital somewhere around a hundred thousand dollars a year to manage drug shortages. And that doesn't count any of my time or any of the time engaging with the clinicians around alternatives when things are significantly short. And it's one of the things that people get cautious about when we talk about a direct supplier inventory management system. The buffer that our big stocks in the basement in the pharmacy provide is a little bit of protection against some of the drug shortages. (Director of Pharmacy, Hospital B)*

Another solution is rationing the drugs which are in short supply. To manage drug shortages, wholesalers keep their stock for longer times and drip-feed their supplies to cope with their current available amount. This process also incurs higher inventory costs on companies as they have to retain their stocks for longer periods to manage drug shortages. The comment below from the Product and Purchasing Manager at Wholesaler/Distributor J provides supporting evidence of the challenge faced:

> *I would say in the last two years we've had to put on at least two staff that have to manage that [drug] constraint because the level of product on constraint or out-of-stock is growing …. And when a product's out of stock again, it sits with the ethical category manager to source alternatives and make sure we've got sufficient stock to cover over the period of time that a contract hold is out of stock …. It could sit anywhere from one to two million dollars' worth of stock that's constrained that we're holding and drip feeding out. It's a fair investment of stock when normally we don't want to be holding any more than three to*

four weeks of stock of anything. So, when you're holding big numbers like that it puts pressure on you, on obviously your inventory and stock turn because it slows down your stock turn. (Product and Purchasing Manager, Wholesaler/ Distributer J)

- **The Reasons for Drug Shortages**

One cause of drug shortages emanates from a lack of collaboration and data sharing among pharmaceutical entities which results in inaccurate demand forecasts. Data sharing across pharmaceutical entities is not effective enough to help manufacturers have a comprehensive outlook about the potential demands to be able to make precise forecasts. As a consequence, manufacturers' imprecise forecasts might result in drug shortages. The Chief Pharmacist at Hospital A made the following comment which testifies to the issue of data sharing:

Manufacturers will know their own consumption, what they're giving out, but I don't think our [pharmacies] usage data going back to manufacturers. And so I guess from a manufacturers' perspective, even though we're all sort of sitting here complaining that we're out of stock and their forecasting is wrong, we have to be fair to say that the quality of the information that potentially is getting fed back may have some gaps in it too. Their forecasting is wrong because they just don't have the data that correctly informs them. (Chief pharmacist, Hospital A)

Another reason for drug shortages stems from generic drug tenders held by HPV which can lead to a monopoly of the market by one manufacturer/supplier. Indeed, suppliers that win a tender have almost the entire market to themselves; however, there are unanticipated problems in shipment/logistics or manufacturing process which might damage drug cargos. As a consequence, the manufacturer/supplier fails to deliver the stock. Furthermore, events such as a sudden epidemic outbreak can drive up the demand exponentially and exhaust the stock at a far faster rate than forecast. In such scenarios, other manufacturers do not have enough stock to respond to the demand which results in a drug shortage. The Customer Service and Logistics Lead at Manufacturer M explained the issue thus:

> *… You can get all the way to here and end up with nothing. In these twelve weeks on the ship if [the cargo] goes outside of 2 to 8 degrees Celsius you lose the lot. Even if you're using air freight. We've changed our air freight route. … They'll leave it [the cargo] next to the plane before they load it and it's cooked, it's gone. So, say we've got fifty percent of the market and Manufacturer X has fifty percent of the market and they lose a batch, now we've got a hundred percent of the market. Where do we get that extra batch from to fill that? We don't. We sell our stock twice as quickly and then we go out of stock. So that's why we have out of stocks. Or, if there's a disease outbreak like meningococcal disease outbreaks and as soon as one child dies and it's in the newspapers, we could sell a hundred times what we were selling the week before but we weren't able to forecast that. So, you can quickly use up your stock very, very quickly. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)*

The cross-case analysis vividly delineates the challenges that drug shortages pose to pharmaceutical entities. The absence of effective collaboration and data sharing among entities often implies that organisations have to spend high amounts of their budget on dedicated staff members whose role is solely to manage drug shortages or seek alternative supplying methods which both impose costs on organisations.

- **The Positive Impact of BDA on Planning: Hospital Pharmacies**

The application of BDA to the pharmaceutical healthcare sector can be categorised into two sections: clinical and supply chain. Currently, BDA is partially utilised in clinical research to assess the efficacy of new drugs. However, the supply chain part trails behind in the application of BDA which is yet to be fully introduced into pharmaceutical supply chain operations to yield positive outcomes. One of the distinct advantages is the availability of accurate and real-time data among pharmaceutical entities. Wholesalers and manufacturers can have visibility over the types and amounts of drugs that have been used in hospitals in real-time to adjust their replenishment request and forecast their demands accordingly. The Chief Pharmacist at Hospital A explains the benefits of BDA in clinical research, and more importantly, in the supply chain arena:

> *The two areas where big data analytics could be used is sort of the clinical component; so aggregating outcomes of usage and trying to make assessments as to whether the drugs are actually effective or not because we're often spending millions of dollars, but we're actually not turning around and asking the question has it worked.... But that's more of the clinical area, and if we look at the logistics area, it's about making sure all parties involved have access to free-flowing information as real-time as we can get. So, as usage changes at our end that companies are getting that direct and real-time data back so that they can start to model and change their forecasting as well. (Chief Pharmacist, Hospital A)*

Another advantage of BDA is addressing the challenge of drug shortages which, as outlined earlier, is the most significant recurring issue affecting the pharmaceutical supply chain identified by all informants. The interviewees stated that manufacturers tend to not reveal any indication of a drug shortage until it occurs. To address this issue at the national level, TGA (See Section 2.7.1) is taking action on drug shortages by implementing a mandatory reporting initiative which requires manufacturers/suppliers to report potential stock shortages early; otherwise, penalties might apply. Previously, this reporting mechanism existed, but it was voluntary and only a few manufacturers/suppliers reported shortages; however, as of January 2019, it has become compulsory to report shortages which may prove to be a positive step in mitigating drug shortages. Additionally, at the state level, organisations such as HPV are trying to place key clauses into contracts to protect the state against drug shortages. For instance, a manufacturer that wins a tender and contracts with HPV is required to supply the agreed stocks; otherwise, it must pay the difference if there is a reasonable substitute product available in the market. In a drug shortage situation, when a manufacturer fails to supply the market, other manufacturers, which might be one or two, may have to face a greater degree of demand than they had initially forecasted, hence their failure to supply a sufficient quantity of drugs. BDA can provide transparency as to drugs' availability and consumption rate. The possibility of efficient data sharing among pharmaceutical partners, where wholesalers and manufacturers can monitor what hospitals are using, can

materialise through BDA whereby manufacturers and wholesalers can prepare for the supply of the drugs that hospitals are likely to run short of. The key role of BDA to tackle drug shortages is elucidated in detail by the Director of Pharmacy at Hospital C:

> *One of my biggest problems with drugs with outages is that it happens and it's secret until it becomes impossible to keep it secret any further. So then you get people stockpiling or panic buying. … The first time we know about it [drug shortage] is when we go to order it from a wholesaler and they say don't have any stock. Now the manufacturer's known for a long time that their stock levels are dropping and dropping and dropping and reaching a critical point. They can see where their deliveries are and all the rest of it, but they will sit on their hands until it becomes impossible to do anything. And big data analytics and feed around that whole supply chain would make my life a whole lot easier. Equally for suppliers, if they had some visibility of what the Hospital X actually uses, then they'd have greater confidence in controlling access when their things are getting shorter or they can forecast a whole lot better of what goes on. … So greater transparency in that space would make life a whole lot easier. … My take on it is that big data analytics are not the solution to all my problems but they will make things a whole lot better around supply chain management and procurement. … My vision is that a supplier would be able to see what I've consumed and prep for my likely replenishment request, so that there's complete clarity in the supply chain around it. And what I'd like is having integrated systems that are collecting big data and analysing big data. (Director of Pharmacy, Hospital C)*

- **Wholesalers**

Wholesalers also identified the advantages of BDA adoption. Effective implementation of BDA can lead to demands being more transparent at each hospital which, in turn, improves planning processes. This will contribute to efficient inventory and human resource management in warehouses as well. Due to a lack of transparency over hospitals' demand, especially around peak times, too many staff members are allocated to warehousing tasks who could otherwise be deployed to other areas. Better planning results in more accurate forecasts, reduced inventory, and labour costs. The Product and Purchasing Manager at Wholesaler/ Distributor J exemplifies the advantages of BDA in the following comment:

> *If your big data analytics are better, then you can do many things, so you can either hone in on reducing your inventory. You can perhaps not staff as heavily like if you have visibility of customer demand and drops in demand, you wouldn't necessarily have to staff your warehouses as high as you do at times. So if you had a team of people that were actively using big data to forward forecast, then across the whole supply chain you could improve. … If you had more visibility of what was going to be available to you, you could make decisions on the purchasing or where you needed to have stock to cover customer demand … you could plan better. (Product and Purchasing Manager, Wholesaler/ Distributor J)*

Wholesalers also expressed a positive perspective towards the role that BDA can play in tackling drug shortages. Although BDA cannot completely eradicate the occurrence of drug shortages, it can definitely provide more transparency about the market to address drug shortages and alleviate the negative impacts. The role of BDA in addressing drug shortages is delineated in the following comment:

> *I personally think big data analytics will reduce the pain [drug shortages]. If the big data analytics is not in one organisation, but if all the organisations have it or it was collectively outside and the whole information was at one place, then it will minimise the pain; because the people who make a decision that this drug is going to be short for such a length of time [often make these decisions without adequate data]. Then what can we do that we use it only for this particular indication; and in the meantime for other indications we can use another drug for which we can see we have enough stock to cover. So it will help minimise the pain, but I don't think it can eliminate because the problem is slightly more entrenched. (State Manager Hospitals in NSW, Wholesaler/ Distributor I)*

- **Manufacturers**

Similar to hospital pharmacies and wholesalers, manufacturers in this study indicated that BDA can offer better visibility over market demands and ultimately lead to quicker and more efficient decision-making about the planning process. This fact was highlighted by all the interviewees from the manufacturing sector as they are pressured to supply drugs when a shortage occurs. However, to produce drugs, manufacturers will have to re-kit their production processes, requiring a lead-

time of six months. Evidently, BDA will be an asset to them as it provides predictive decision-making capacity rather than reactive decision-making. In essence, predictive capability can greatly improve demand forecast and planning and also save costs by minimising the number of drugs that are wasted due to expiration. This vision can be realistically achieved through an integrated supply chain where information systematically flows back and forth among the entities involved, especially manufacturers who invest heavily in the manufacturing of drugs. The Customer Service and Logistics Lead at Manufacturer M elaborated, at length, on BDA yields for manufacturers:

> *You'll get better planning because you have better visibility because you can see what's happening further away from you. Really that's what it's all about, being able to identify things that are happening. It's when you need to make decisions around when things don't work well … the sooner you can find out that something bad is gonna happen, the quicker you can react to it. That's what big data analytics will give you. As soon as you can identify a change further down the supply chain, the quicker you can react to it. With those lead times of twenty-four weeks or whatever, if I can save three weeks because I know the pharmacies have started running out of stock or there's an outbreak or somebody else has gone out of stock-- if I can save three weeks that's three weeks that the country has stock; it just means that out-of-stock is three weeks shorter because I found out about it three weeks earlier. And on the flipside the more we share data and the better we get our forecasts, the less waste there is in the system as well. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)*

The cross-case analysis demonstrates that the current demand forecasting is based on historical data which does not neatly tally with actual demands and might result in drug shortages. The informants explicitly identified the potential benefits that BDA adoption can offer in the planning process indicating that BDA can facilitate the availability and flow of real-time data and significantly improve the accuracy of demand forecasts. Indeed, BDA can create a dynamic forecasting model where adjustments by manufacturers can be made in real-time to respond to market changes which reduce the likelihood of drug shortages. Also, the informants confirmed

that BDA adoption can make improvements in human resource management and inventory management and reduce their costs in these areas.

4.3.2 Source

- **Hospital Pharmacies**

Sourcing drugs in Australia is not a very straightforward process. All kinds of drugs are regulated by the TGA. Only the drugs that are registered on TGA can be purchased and used. Therefore, a company that supplies any drug to be marketed in Australia will need to make an application to the TGA to have the product registered. The process is the same whether the product is a new drug or an existing one, or whether it is made in Australia or imported from overseas. The TGA then considers the efficacy and safety of the drugs and determines which drugs are allowed to be used in Australia.

Given that some drugs are too expensive to be widely used, there is a government scheme known as the PBS which subsidises some drugs (See Section 2.7.1). The PBS determines whether any given drug is cost-effective to be subsidised and used in Australia. It must be pointed out that it is not only costly drugs that are subsidised by the PBS; the scheme also applies to a wide range of inexpensive drugs. The Chief Pharmacist at Hospital A describes the process as follows:

> *The way that drugs come onto the market in Australia is a two-step process. It has to be registered with the TGA, the Therapeutic Goods Administration. So, they register the drug to be used in Australia. So, that's the first step and that means we could use it in Australia. But for the most part, all new drugs that come out are really expensive and so, they won't get used much until they go onto PBS. So, that's where the government says we'll pick up and subsidise the cost of those drugs. (Chief Pharmacist, Hospital A)*

There are two types of drug categories that TGA approves for use: originator drugs and generic drugs. The former refers to patented drugs and the latter to off-patent ones. For originator drugs, there is only one manufacturer which holds the patent, and therefore hospital pharmacies purchase their required drugs either directly from the manufacturers or wholesalers. As for generic ones, hospital pharmacies in Victoria generally follow HPV contracts. HPV is an organisation that facilitates the procurement of drugs and other health-related products through organising important and large-scale tenders to help hospitals in Victoria save costs through centralised contracts with better terms. In the case of generic drugs, where there are multiple brands which produce a certain drug, HPV offers a tender to secure the best price. Hospital pharmacies are supposed to purchase their required drugs from the manufacturers/suppliers that have won contracts through HPV and comply with HPV's contracts. The sourcing process is described in the following statement from the Director of Pharmacy at Hospital C:

> *If they [drugs] are the originator and they [manufacturers]'re the only one with it, therefore, they [manufacturers]'re the ones I'm buying it from, so it becomes a question of whether I buy through a wholesaler or I'm buying directly from them. That really depends on what they [manufacturers] want to do. For HPV lines then it's kind of taken out of my hands because they're all the generic drugs and so it's whatever is on the HPV contract and I follow the contract from that perspective. So, if the source says I have to buy it from Wholesaler X then I buy it from Wholesaler X. If the source says I can buy it from any of the three wholesalers that are in Victoria, then we buy it from our preferred wholesaler because of our relationship with that wholesaler. (Director of pharmacy, Hospital C)*

HPV does not play a very significant role in hospitals' expenditure on drugs. This emanates from the fact that HPV covers only generic drugs and a large proportion of drugs, by volume, in pharmacies are indeed generic ones, which are much cheaper; and they are procured under HPV contracts. In other words, volume-wise, generic drugs are large but cheap. In contrast, from a cost perspective, originator drugs are very expensive and they are not under HPV contracts and

hospitals have to purchase those by themselves. Chief Pharmacist at Hospital A describes volume and cost ratio of generic and originator drugs and the role of HPV as follows:

> *So by volume and by cost, will give very different answers. So if we look at by volume, there it's a large proportion [of generic drugs], I'll just say like eighty percent, so it's probably the majority of things that we use. But by dollars it's actually quite small, and the reason for that is that HPV really only plays in the off-patent space. So when drugs come off-patent, most of those drugs become very cheap, and so, are high volume but low cost. And when you look at your overall spending, the vast majority of our dollars are spent on the patent. So that's why if you sort of did a pie graph you'd actually see HPV looking quite small, but if you looked by volume it's the other way around. (Chief Pharmacist, Hospital A)*

When it comes to procuring originator drugs, hospitals in Victoria do not have to go through HPV. Each hospital pharmacy has its preferred wholesaler that is chosen based on their previous experience with the wholesalers. The most important criteria for selecting a preferred wholesaler are price, reliability, customer service, stock outages rate, and the rate of incorrect picks. Thus, reliability and accuracy seem to be the determining factors for hospital pharmacies to select their preferred wholesalers:

> *So we do have a preferred supplier that's based predominantly on just history with, well-price obviously, reliability, customer service, rate of stock outages or rate of incorrect picks.... So we found that Wholesaler X have been [good], we've used them because their pricing was better. ... We worked with them ... because they've got highly automated systems that didn't cost them a lot extra. So basically, we were able to get that benefit with no extra cost, so we don't pay anything for that. And the processes they've got with, bar code scanning, pick weight checking, and all that sort of things mean that their accuracy is 99.98%. Whereas some of the other companies don't do that, their percentages of picks are lower. (Chief Pharmacist, Hospital A)*

Hospital pharmacies' directors stated that they have an automated system that manages their inventory and generates a daily report of stock levels. Once the drugs reach the reorder point, which is the minimum acceptable level of an item in stock, the pharmacists determine whether or

not they need to replenish the stock. This system also generates stock cards which offer preferred wholesalers/suppliers for each drug to guide the purchasing officers. The purchase orders are sent through Electronic Data Interchange (EDI), a process which allows an organisation to send information to its trading partners electronically, to the preferred wholesaler/supplier. Then, the wholesaler/supplier returns the purchase orders with an invoice to the pharmacies to be signed off and sent to the finance department to process the payment. The process is delineated below by the Director of Pharmacy at Hospital B:

> *So we do have our automated inventory and dispending management system. It has the inventory in it on each site, so each site operates a pharmacy area within the system. And the minimum quantities are kept within that inventory list, and what we do is run an end-of-day report each day and that'll produce a report of all of the items that have hit the minimum quantity. Then, we'll work out whether we want to order it or not, so we don't keep everything on our shelves that is on our formulary. Some things we only order as the patients need them. But for the vast majority of our things, we just do that daily top up. And within the system, there's also what we call a stock card, it's a very old-fashioned term and in fact all of these things used to be on paper before we had electronic systems. The stock card will have the preferred supplier for each item and a next supplier if they don't have it, and then a next supplier if they don't have it, which enables our purchasing officers to raise a Purchase Order to that preferred supplier for that item or lots of items usually. And then that purchase order goes electronically to each of the three wholesalers or one of the other suppliers ... And then the order's collated by them and sent to us with an invoice which is matched to the Purchase Order, electronic signed off by a pharmacist and then sent to finance for payment. (Director of Pharmacy, Hospital B)*

EDI provides a link between wholesalers and hospital pharmacies, enabling hospital pharmacies to see the availability of each drug and its corresponding price. This online portal considerably improves efficiency; eases the process of ordering for hospital pharmacies; removes manual processing; and decreases costs, errors, and the risk of data inaccuracy. The following comment from the State Manager at Wholesaler/Distributor F outlines this process:

All the wholesalers have an online portal which shows visibility of stock on hand and live pricing to that hospital. So they all have their own login. That's what happens at a hospital level.... Order from the hospitals comes through EDI. So they all transact EDI. (State Manager in VIC & TAS, Wholesaler/ Distributer F)

- **Wholesalers**

Wholesalers' process of sourcing drugs from manufacturers depends on several factors. Wholesalers place orders based on (1) their own forecasts, (2) historical data, and (3) the data received from hospitals. They also consider their budget when ordering. The comment provided by the State Manager in VIC & TAS, Wholesaler/ Distributor F, presents the sourcing process:

So, we have minimum and monthly dollar values that we must adhere to. So we can't order out of cycle basically. So we have a weekly order with major manufacturers that have a lot of turnover. We have a fortnightly structure with smaller manufacturers and a monthly structure with the really small ones. So how [do] we manage that? We rely on forecasts, history and basically information coming directly from the pharmacy departments at the hospital. (State Manager in VIC & TAS, Wholesaler/ Distributer F)

HPV also affects the sourcing of particular drugs as it holds tenders for many generic products. There might be several manufacturers that produce a particular drug with the same quality. However, once a manufacturer wins a tender for any generic drug, other wholesalers prefer to work with that particular manufacturer as it helps them to have a much smoother sourcing process. The Business Operations Manager at Wholesaler/ Distributor H explained their sourcing process:

The ones [manufacturers] with HPV or any the State board tenders is [our preference]. That's because there's multiple [manufacturers]. In some molecules there can be multiple options of which item to use for the different generics. We know if this [manufacturer] is the awarded one, all of our volume is going to be on that line rather than us having to hold ten different molecules of the same one. We only have to hold that particular one. So, say, you've got something like Simvastatin which is the molecule of the drug ... I think Simvastatin has about ten different manufacturers of the same product, so there's Sandoz, Apatecs, Genarex, Duno.... There's about ten different brands that manufacture that same

product, same strength, exactly the same thing. But only one is awarded it on the tender. So instead of us having to arrange all twelve different brands of it, we only need the one. (Business Operations Manager, Wholesaler/ Distributor H)

- **Manufacturers**

Most manufacturing companies are international companies with their headquarters based mostly in Europe or the USA and several hubs/sites around the world which all manufacture drugs. Most of the raw materials for pharmaceutical manufacturers are imported to Australia. Additionally, the majority of drugs are brought through Australian pharmaceutical companies and distributed out to the customers either directly through manufacturers or third parties such as DHL. The following comment from Pharmacy Inventory and Systems Lead at Manufacturer N demonstrates their sourcing process:

In terms of sourcing, all our suppliers have one to five-day turnaround time. So when we place the orders, we source it from local third party suppliers or it can be our company products sourced from overseas or it can be our company products manufactured locally here. So, a number of sources are being used to get the material in. (Pharmacy Inventory and Systems Lead - ANZ, Manufacturer N)

Customer Service and Logistics Lead at Manufacturer M also echoes a similar sentiment:

We have a manufacturing site here for pharmaceutical products, and I think it supplies out to a hundred and twenty different countries. But it only provides five percent of its medications [to be] used in Australia, so we have to source ninety-five [percent] of our own medications from everywhere else in the world. We're still considered to manufacture a lot of drugs in Australia. There would be a lot of pharmaceutical companies that don't manufacture anything in Australia and they'd bring them all in. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)

The cross-case analysis of informants' responses reveals that they did not identify any potential benefit that BDA adoption can bring to their sourcing process. The reason for the absence of BDA

opportunities in the sourcing process in the Australian pharmaceutical context will be discussed in Chapter 5.

4.3.3 Make

- **Hospital Pharmacies**

The process of manufacturing drugs is, for the most part, a relatively straightforward one. The vast majority of drugs are produced in manufacturing sites in a certified facility on an industrial scale, which helps the price to remain at a reasonable level compared to the drugs made in pharmacies. However, there are compounding drugs, which are custom-made drugs designed for the needs of a unique patient, which might be made in hospital pharmacies such as intravenous products. The production of such drugs depends on many factors as indicated by the Director of Pharmacy at Hospital C:

> *Obviously there are some things [such as drugs][that] come pre-made because we buy a bottle of pills or a tube of cream or injection or something like that. But there are some things that we compound- so like chemotherapy for example or TPN for patients that require intravenous feeding. Obviously, that making is based on having patients here and having a doctor's order, so that depends on who is in the hospital, who we're treating and that defines what we do in that space. And obviously, I need to have the ingredients to do that and that's all dependent on what we know historically and what we know is going to happen. (Director of Pharmacy, Hospital C)*

- **Wholesalers**

A wholesaler receives a large number of orders daily from different hospitals across the state. Such orders include various products in various quantities. Depending on wholesalers, the orders can be processed either (semi)automatically or manually. The (semi)automatic processing involves

equipment in the distribution centre which selects the medicines from stock shelves in warehouses and loads them into a tote allocated to a specific hospital. This process significantly increases accuracy and efficiency. However, during a manual process, a staff member goes through warehouse aisles and shelves to locate the medicines and load them into totes—a process which is not entirely error-free or efficient. The efficiency of (semi)automatic processes, which are already in use in a few wholesaler centres, is assessed in the following statement from the State Manager in VIC & TAS, Wholesaler/ Distributor F:

> *So we scan each product when it gets delivered … to make sure we've loaded it into the correct tote internally in our DC [Distribution Centre]. The computer knows where that tote is, and then it will spit out product. If Hospital A orders twenty of those, it'll spit out that product. Then, that product being picked goes through six check weigh stations and if there's any weight variances at all by the time it fills up, it gets quarantined. And then we have a picker check individually. So we've got 99.9% accuracy in our DC, whereas in a manual environment it was only averaging about 92% because they're still working in a manual environment. So from that point of view, our processes work pretty well in the assembly part. (State Manager in VIC & TAS, Wholesaler/ Distributer F)*

- **Manufacturers**

The process and production time of manufacturing drugs can vary significantly depending on the type of drugs. Compounding drugs can be produced in a very short time and manufacturers can dispatch them to where they are needed at a short notice as demonstrated by the following comment from the Pharmacy Inventory and Systems Lead at Manufacturer N:

> *In terms of make, we've got eight compounding centres across Australia and New Zealand: six in Australia and two in New Zealand. And we make the actual product, the finished goods from our perspective, as soon as we receive the order, and it depends on when the customer needs it. Say, the customer needs it the same day, we will manufacture [it on] the same day. If the customer needs it the following day depending on the time, if they need it at 10pm, we manufacture in the morning and send it out. (Pharmacy Inventory and Systems Lead - ANZ, Manufacturer N)*

On the other hand, manufactured drugs and vaccines entail a different process which is sometimes very costly, time-consuming, and also risky. Making a vaccine can take between six to nine months, costing several million dollars. As hundreds of millions of dollars are invested in manufacturing sites, manufacturers try to run the site at almost full capacity. Therefore, manufacturers need to have accurate manufacturing forecasts and plan for the whole year to mitigate the risks and increase benefits. The following comment from the Customer Service and Logistics Lead at Manufacturer M confirms the difficulties associated with manufactured drugs and vaccines:

> *It's not like making cars. When you make a car, you know that you take four tires, a steering wheel, some doors, some metal, you'll come out with a car. You might put in a million dollars' worth of raw materials to make your measles, throw your measles in, and at the end you assay it. You say, well how much measles do I have, you might be trying to make ten units, you might get twelve which means you can make more vaccine; but you might get seven. It's a biological system, and you don't know what you're going to get. But importantly you might also get zero. It might become contaminated by another bacteria or it might not grow so now you start again. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)*

The cross-case analysis of informants' responses reveals that they did not identify any potential benefit that BDA adoption can bring to the make process. The reason for the absence of BDA opportunities in the Australian pharmaceutical context will be discussed in Chapter 5.

4.3.4 Deliver

- **Hospital Pharmacies**

Delivery of drugs from hospital pharmacies to different wards is facilitated through internal medication rooms and departments within the hospital where drugs are used. These rooms have an

area commonly referred to as ‘imprest cupboards’. Hospital pharmacies have an established list of drugs with a minimum and maximum level for each drug that is all stored in their imprest cupboards. The pharmacy technicians manage those imprest areas by checking them daily. Each product has a barcode label which is scanned by pharmacy technicians to determine which drug needs to be replenished and what quantity is required. If one ward requires commonly used and less costly drugs, they are delivered from the bulk inventory area to imprest cupboards and nurses are, then, able to deliver these drugs to their patients. However, if a patient requires a unique, expensive, or less commonly used medicine that is not available in the imprest cupboard, the ward pharmacists take an order for that drug and directly dispense it to the patient. These two types of deliveries within hospitals are depicted by the following comment from the Chief Pharmacist at Hospital A:

> *We have medication rooms or drug rooms on the wards and they have what we tend to call imprest cupboards. So that’s where we don’t issue a drug to a patient. We would issue drugs from here [pharmacy] to a ward. And so a nurse might have a drug chart, so if [it is] … sort of cheaper commonly used medication, we wouldn’t waste a whole lot of time dispensing the medication to a person. They [nurses] would just go into the medication room which is separate to our pharmacy satellite; they’re two separate areas, and they [nurses] would just basically get [the medicine] off the shelf, bit like a pantry … so that sort of delivery is usually one of two ways. The other one is patient specific dispensed medication that we would do, we’d put a label on, and that would be probably for higher cost or more rarely used medications. If it’s common, it would be coming from the imprest in most of the areas. (Chief Pharmacist, Hospital A)*

- **Wholesalers**

Wholesalers make deliveries to both retail pharmacies and also hospital pharmacies. Delivery to retail pharmacies depends on their geographical location which might take 24- to 48-hours. Deliveries to hospital pharmacies, which is the focus of this study, differ slightly as wholesalers

make two daily deliveries—namely, an 'a.m. delivery' and 'p.m. delivery'—instead of single run. When the order is processed and ready to be dispatched, wholesalers notify hospitals to allow them to organise the reception of the delivery. However, there are unanticipated circumstances such as traffic that might affect delivery time. In such cases, wholesalers and their delivery service will be in contact with the hospitals to update them about any potential delays and the new delivery time. The comment provided by State Manager in VIC & TAS, Wholesaler/ Distributor F, provides a picture of wholesalers' delivery process:

> *We can guarantee that if a retail pharmacy orders it [a drug], they will have it within twenty-four hours no matter where they're located. There are exceptions because some are … in the middle of nowhere, so forty-eight hours. But metropolitan, we have to provide as soon as the retail pharmacy orders it.... Hospitals are a little bit different because we provide them two deliveries per day, so they get an a.m. delivery and a p.m. delivery. Once we pack it and the driver's left, we send an automatic email to the hospital to say that the driver's left. And we inform them if they're departing late too. So, if they're half an hour late, we let the hospital know because … they work their staff around our delivery basically …. But we can't control once the driver leaves and he's in traffic. So they'll ring us if it's late and then we follow up backwards basically. Get in contact with the DC; they get in contact with the driver to see where he is. So a lot of it is manual and spur of the moment decisions that we need to make. We tell a hospital they have to order by 11.30 [to] have their order by 2 o'clock that same day, or have to order by midnight to get it by 8 or 9 am the next morning. (State Manager in VIC & TAS, Wholesaler/ Distributer F)*

- **Manufacturers**

Manufacturers' delivery process mainly depends on the type of customers they interact with. The main customers of pharmaceutical products are categorised into three major groups: major wholesalers and small distributors, large compounding pharmacies, and public/private hospital pharmacies and community pharmacies. Some manufacturers have outsourced their warehousing and distribution to a third party such as DHL and Toll Logistics. The Head of Supply Chain at Manufacturer L reflected on the delivery process in the following statement:

> *So we've actually just recently outsourced our logistics and warehousing and distribution to a third party, DHL. But up until September this year, we'd been distributing out of our own in-sourced facility for sixty four years. It's using DHL for the warehousing activities; it's using Toll for air freight. (Head of Supply Chain, Manufacturer L)*

The National Sales Manager at Manufacturer K also made a similar comment regarding their delivery process:

> *Delivery is as per order. So if a customer orders we deliver. We have hired someone to do our deliveries into all the hospitals and that's DHL. (National Sales Manager, Manufacturer K)*

However, other manufacturers prefer wholesalers for delivery and distribution. Choosing a distributor depends on the state and whether the drugs are procured under tenders from HPV in Victoria or direct state government tenders in Tasmania. In case the drugs are procured through tenders, manufacturers use their preferred wholesalers to supply hospitals. However, for drugs that are not on tender, manufacturers usually follow hospitals' preferred wholesaler. The following statement from the Key Account Manager at Manufacturer O demonstrates the delivery process:

> *So, we do work with HPV and we have products across various tenders with HPV, but also with bodies such as directly with the State [like] in Tasmania where you've got the tender with the State of Tasmania and then they supply the various hospitals affiliated to that. We do that through a preferred wholesaler, Wholesaler X who manages our stock for us, whether it's for the HPV or whether it's for other arrangements. For other arrangements that fall outside of the tender, or the state tenders… it's up to the hospital to choose who they want to work with. And then we will supply those wholesalers with our products so the hospitals can access the products with their preferred wholesaler, so they are getting the benefits. Many organisations will choose one wholesaler to partner with and they will order majority of their drugs. The more they use that particular wholesaler, potentially there might be … better benefits for them. So, we're happy to work with who they want to work with. (Key Account Manager, Manufacturer O)*

There is, however, one exception to this distribution model. Unlike all other Australian states and territories where wholesalers are allowed to supply public and private hospitals, in Queensland the

process is different. In this state, there is a centralised warehouse model which purchases and stores pharmaceuticals from manufacturers. It then supplies the products back to public hospitals. Therefore, wholesalers cannot supply public hospitals directly; instead, they have to supply this central warehouse and public hospitals are then obliged to purchase products from this centralised distribution model.

Location and geography also play a very important role in the delivery of drugs across Australia. This factor can affect both the means of transportation and the time of delivery. For instance, for the metropolitan area, special vans are deployed which are appropriate for carrying drugs. As for the regional areas, even air transport is used to supply hospitals in the shortest possible time. Pharmacy Inventory and Systems Lead at Manufacturer N emphasises the critical importance of location in this comment:

> *It [delivery] depends on the location of the customer as well. Geography is very important to our business so we cater for metro customers by dedicated delivery vans. Because they are all medications, we have different dispatch times throughout the day and metro deliveries happen as they manufacture …. For the regional ones, it's a little bit different, of course … there's a combination of road; our courier company will use air transport as well, so it gets flown into various regions. So usually our target is to deliver aspects of customer requirements, but it generally does not take any more than twenty-four to forty-eight hours from the time of dispatch. (Pharmacy Inventory and Systems Lead - ANZ, Manufacturer N)*

- **The Positive Impact of BDA on the Deliver Process: Manufacturers**

Manufacturers accentuated the benefits of BDA in improving decision-making regarding the launch of new products and drug distribution. The introduction of a new product requires copious of information about the targeted demographics, high demand areas, location, and the mode of transportation which depends on the type of product. BDA can supply meaningful analyses for

better decision-making regarding the logistics of new drugs and methods of dispatching them to consumers. The significance of BDA in this regard is underscored by the Head of Supply Chain at Manufacturer L:

> *I think we've launched some fairly significant products in the last few years and in each of those scenarios really assessing what's happening out in the marketplace, number of patients, age, demographic, geographical location, all of these factors are very much being considered …. So data's being assessed from a supply chain perspective fairly basically, but just understanding what the cost drivers will be; for example, if we're looking at multiple sclerosis, where's the largest patient group, what State are they in, are they predominantly metro or regional based, how's that driving supply chain costs, what are the considerations, if it's a cold chain material, what are the tolerances around that cold chain material, if we're needing to get to remote places. So a lot of it is some of that sort of demographic, geographical analysis and certainly big data is giving us the insight into those sorts of things to make the right decisions around distribution. (Head of Supply Chain, Manufacturer L)*

The cross-case analysis reveals that manufacturers can benefit from BDA adoption in their delivery process. BDA can provide useful logistics and demographics data regarding the target audience. Wholesalers and hospital pharmacies did not identify any benefits in the delivery process.

4.3.5 Return

- **Hospital Pharmacies**

Hospital pharmacy returns either relate to the drugs that are returned from wards to the pharmacies, or the drugs that are returned from pharmacies to manufacturers/wholesalers. There are several reasons for returning drugs to wholesalers/manufacturers including pharmacies' errors in ordering, delivering wrong types of drugs, and supplying short-dated drugs by wholesalers/suppliers. Suppliers have their return policies and generally accept the returns of wrong order or wrong delivery; however, they are not willing to accept back refrigerated drugs due to the difficulties of

the cold chain. The return process is described by the Director of Pharmacy's comment at Hospital C:

> *Returning things to the wholesalers, all of the suppliers will have returns policies. If we've ordered something in error or if they've supplied something in error then we would send it back and apply for a credit. They're reluctant to take refrigerated items back, in fact most of them won't take refrigerated items back because of the supply chain temperature control processes. (Director of Pharmacy, Hospital B)*

The return mechanism from wards to pharmacies within a hospital presents some complications in terms of resources and costs. As outlined earlier, drugs within a hospital are delivered to patients from either imprest cupboards or pharmacies. When it comes to returns, hospital pharmacies only accept expensive drugs and reissue them back into their inventory system. Otherwise, cheaper drugs are not reissued back into the system since the cost and amount of required effort is not proportionate with drug costs. Such drugs are marked to indicate they are not in the inventory system and are then re-dispatched to the wards whenever requested. The Director of Pharmacy's at Hospital A demonstrates this point:

> *From the ward to here [hospital pharmacy], we would put back into inventory items that are expensive where there is a threshold. Things that are not terribly expensive, we'll mark with a dot actually to indicate that they've already been entered out of our system. Then if another patient needs that medicine, it just gets taken up to the ward. So that's an economics thing really more than anything else. The effort required to put it back in the system and then reissue it is substantial, so we don't do it. (Director of pharmacy, Hospital B)*

- **Wholesalers**

There are several reasons why products are returned by wholesalers to suppliers. There are occasions when suppliers and wholesalers have a mutual agreement to sell a particular item within a timeframe agreed upon by both parties. In case the drug is not sold within the agreed period time,

the wholesalers return the drug to the suppliers. Returns may also occur due to quality issues or if suppliers overstock wholesalers. A further reason for a return is sending the wrong drugs or short-dated stock to wholesalers. With regards to short-dated stock, the supplier agrees to accept the returns of drugs that are not sold before their expiry date. This process and reasons for a returned order are explicated by the Product and Purchasing Manager at Wholesaler/Distributor J:

> *To return stock to suppliers … there's multiple things. So, if the supplier has asked us to put [a] product into [the] store and that has not sold … at the end of the period that we agreed to with the supplier, then we will initiate returns to suppliers. So, that data's crucial; we don't have a clean system for that process at this time, [and] it is quite manual. So again, it's something that our analysts in purchasing look after. There's also recalls, [and] that's handled by our quality area. If a supplier overstocks us or supplies the wrong product, that's not really entered into the system.... And the other facet is where we get short dated stock. So, we keep a register of when a supplier sends product with less expiry than agreed, and we will then record that and … We provide the supplier with a letter, so it's through like an emailed letter asking them to bear responsibility if that product doesn't sell before it expires. So, that is tracked through an online tool. The supplier signs off; we then OK [it]; so procurement then OK's that product to be receipted and then our stock control area manages that product to expiry. So, hopefully you sail through it so they will manage that through an online tool. (Product and Purchasing Manager, Wholesaler/ Distributor J)*

- **Manufacturers**

The return process depends on the type of drugs that are manufactured. In compounding organisations, drugs are made based on patients' specific needs. Therefore, in the case of returns, manufacturers have to discard these products (or manufacturers are generally reluctant to accept returns) since compounded drugs cannot be used by others. This fact was indicated by the Pharmacy Inventory and Systems Lead at Manufacturer A:

> *In the compounding business, if we have made our product, we wouldn't take it back because it's patient specific. So probably the chances of the same formulation to go into*

the next patient is very limited, so we wouldn't be able to accommodate it from that perspective. But then generally if we're sending other things which are common to the wider market … yes, we've got defined process of managing the returns and the credit processes. (Pharmacy Inventory and Systems Lead - ANZ, Manufacturer N)

On the other hand, organisations generally have a return policy in place to deal with drugs that are more widely used. This policy normally applies to defective drugs, or errors in the ordering/delivery process, as it is demonstrated by the National Sales Manager at Manufacturer K:

If there's a fault with the product, of course we accept returns. So generally speaking, we would not accept a product because of its expired date. A customer could return it if they had made a mistake in their order, but generally Manufacturer X then will destroy that product because it's left our hands. So basically, we're very careful with return policy. (National Sales Manager, Manufacturer K)

It should be noted that since some of the drugs are manufactured outside Australia, it is the cost of exporting the returned drugs back, rather than the inventory costs, which is significantly high for manufacturers. The temperature control shipment for drugs, as well as country-specific packaging, makes it costly to export the returned drugs to other destinations. The Head of Supply Chain at Manufacturer L outlines some of the difficulties involved:

The cost of us storing a pallet of stock is really nothing. It's around five dollars a month. So the cost of then exporting that back for somewhere else to use is extremely costly. You've not only got the temperature-controlled freight of getting it to another location, [but also] that has to get to a rework facility. It has to be reworked to local packaging. So the only market where we can use stock that's come into Australia is Australia and New Zealand because of the packaging. (Head of Supply Chain, Manufacturer L)

- **The Positive Impact of BDA on Return**

Some of the issues that are accompanied by the return process are outlined above, the most common of which was short-dated drugs. These drugs have to be discarded, incurring considerable

costs on pharmaceutical entities. Currently, in Australia, hospitals rely on medicines' barcodes which only identify the products without any further information. However, when 2D barcodes are used in Australia, they can provide a volume of useful data including the origin and expiry date of products. The use of 2D barcodes can increase the volume of available data and generate big data whose analysis assists hospital pharmacies in the return process. For instance, BDA allows hospital pharmacies to reject short-dated drugs or dispatch short-dated drugs to areas where the drug is in high demand. The following informant from Hospital C illustrates the benefits of BDA in the return process:

> *And obviously if I knew -- even down to expiry dates. When we talk about return at the moment, the expiry date is not electronically recorded because the barcode that we use only identifies the product; but, if we were using 2D barcodes, then we'd have [the] source of manufacture, date of expiry, and all that sort of stuff. So once that's captured, then I know what stock is floating around as it comes through the door-- whether it's short dated (in which case I shouldn't be accepting it) or [if] I should be flagging it up and moving it directly to a high use area and pulling stock out of other areas so that I don't get stuck with it when it hits expiry. So, there's a whole lot of things that big data analytics would help me in that whole space. (Director of Pharmacy, Hospital C)*

It must be noted that Australian pharmaceutical participants, unlike their European and American counterparts, do not use 2D barcode as it is not mandated by TGA. These barcodes generate granular levels of information about product weight, dimensions, production/expiry date, etc. Analysis of the big data generated from 2D barcodes enables an efficient procurement and return process. In this fashion, even short-dated drugs are more efficiently distributed and used, which saves pharmaceutical supply chain entities large amounts of money by not having to discard the returned expired drugs. It can also deter counterfeit products from entering the market. The Director of Pharmacy at Hospital C explains the benefits of access to BDA and the current challenges encountered, due to a lack of data:

> *So TGA don't mandate. The Europeans and the Americans require the use of 2D barcodes which has more than just the drug identifier, and Australia hasn't done that yet. And once that happens is then you get a whole lot of data around the product, so not just the identifier, but you also get batch number and expiry date and all that sort of thing. So for recalls, stock management becomes a whole lot better. In actual fact from a point of view of adverse drug reactions, if you were capturing the barcode when you were administering to the patient … you would know what batch number was given to that patient and what expiry date, where it was made and all the rest of it. At the moment we can say we gave you the drug, we couldn't tell you which expiry date it was, what batch number and whether it came from Spain or Italy. If there was a problem, it would be really difficult. It'd also protect us against counterfeit drugs too. (Director of Pharmacy, Hospital C)*

In the same vein, the following comment from Customer Service & Logistics Lead at Manufacturer M also gives evidence to the advantages of BDA in the return process:

> *The more we share data and the better we get our forecasts, the less waste there is in the system as well. People aren't investing money, time, energy, buying products that aren't gonna be used and they're gonna eventually get thrown out because they all have expiry dates on them; and some of them are really expensive drugs. When I go and talk to the wholesalers, they'll say to me, we've got three packs of this HIV drug that's worth a thousand dollars a box, and they're not selling in Perth. … And I might go and look at my analytics and say well they sell a lot of it in Sydney. If you can move it to Sydney, you'll probably get rid of it. So that's how big data analytics can help. Better forecasts mean there's less waste. (Customer Service & Logistics Lead - Intercontinental Supply Chain, Manufacturer M)*

The cross-case analysis demonstrates that BDA adoption can assist pharmaceutical supply chain entities in the return processes by identifying short-dated drugs and making efficient use of them before they reach their expiry date. This can save organisations huge amounts of money by not having to discard drugs. Through BDA, organisations can also identify areas where some drugs are in more demand and therefore, dispatch drugs to those areas before drugs reach expiry dates, thus saving more costs.

4.4 Summary of Chapter

This chapter sought answers to two main questions which were designed to support the conceptual framework of this research. The main ideas explored in this chapter included: the determinants of BDA adoption and the benefits offered by BDA to improve decision-making in supply chain processes in the Australian pharmaceutical context.

This research draws upon technology-organisation-environment (TOE) framework to investigate the determinants motivating or hindering the adoption of BDA in Australian pharmaceutical entities. The TOE framework is categorised into three contexts which are comprised of technology, organisation, and environment context. The cross-case analysis of the findings revealed that the technological context includes 1) relative advantage, 2) compatibility, and 3) data quality; the organisational context encompasses 1) top management support and 2) organisational readiness; and the environmental context encompasses 1) government policies and regulations and 2) trading partner pressure.

The findings revealed that Australian pharmaceutical entities have a reasonable understanding of the advantages that BDA adoption can provide. Relative advantage is considered to be one of the most significant factors which motivates Australian pharmaceutical entities to adopt BDA. The analysis also suggests that BDA adoption is consistent with some manufacturers' and wholesalers' existing values and their needs which increase their adoption intention.

The informants indicated that they do not have sufficient access to accurate and real-time data. Consequently, manufacturers are not able to forecast accurate demand, resulting in frequent drug shortages which adversely affect patients and pharmaceutical entities. The findings demonstrated that higher levels of data quality can lead to higher intention to adopt BDA.

The findings also revealed that to adopt BDA, traditional technologies and tools are insufficient; organisations need to upgrade their IT infrastructure. Moreover, access to skilled human resources with literacy in BDA is identified as a significant factor for BDA adoption—especially skilled human resources who are also proficient in domain knowledge such as supply chain management and healthcare. A combination of robust IT infrastructure and professional analytics motivates pharmaceutical entities to adopt BDA. Australian pharmaceutical entities are equipped with varying levels of organisational readiness including IT infrastructure and skilled human resources. Manufacturers have higher organisational readiness; however, moving down the supply chain stream, the level of technological maturity declines markedly in hospital pharmacies. Furthermore, top management support is recognised as another important factor for BDA adoption. Implementation of BDA requires a considerable amount of investment for upgrading the IT system, recruiting data scientists/analytics professionals, and holding training programs for current employees. Therefore, without the support of top management, BDA adoption is unattainable. The findings further revealed that hospital pharmacies are the recipient of government funding which makes service quality of seminal importance—hence, the lack of incentives to invest in BDA adoption.

Environmental factors also play a crucial role in BDA adoption intention. In this research context, these factors are mainly associated with government policies and regulations, and trading partner pressure. Given the important nature of the pharmaceutical healthcare industry, it is heavily regulated and requires strict compliance with regulations. This rigid regulatory framework currently poses a challenge to BDA adoption. However, government policies and regulations can support and facilitate BDA adoption. According to the analysis, trading partner pressure can also motivate pharmaceutical manufacturers to adopt BDA.

BDA can also improve decision-making in supply chain processes. This technology enables pharmaceutical entities to have better access to accurate and real-time data which exponentially increases their planning process and enables them to have accurate forecasts. More accurate forecasts will significantly improve decision-making that enables organisations to source and manage their stocks more efficiently to fulfil demands and avoid drug shortages or stock scarcity, which, at present, adversely affects the industry. Improved decision-making can also optimise human resource management, increase visibility over stock, and reduce drug shortages.

Chapter 5

Discussion

5.1 Introduction

This chapter presents a detailed analysis of interview findings by comparing them with the extant literature to validate the findings and also develop propositions relevant to each research question. The research questions are as follows:

- RQ_1: What are the determinants of BDA adoption in the Australian pharmaceutical supply chain?

- RQ_2: How does BDA improve decision-making across supply chain processes (SCOR processes: plan, source, make, deliver, and return) in the Australian pharmaceutical supply chain?

The structure of this chapter is as follows: Section 5.2 presents the determinants of BDA adoption based on the TOE framework in the context of this study. Section 5.3 details the potential benefits of BDA adoption and decision improvements it can make in each SCOR process (i.e. plan, source, make, deliver, and return). Section 5.4 presents the revised conceptual framework based on the analysis of interview findings. Section 5.5 presents a summary of this chapter.

5.2 Determinants of Big Data Analytics Adoption

This section analyses the interview responses to RQ_1. This study investigates the determinants which motivate or hinder the adoption of BDA in the Australian pharmaceutical entities

(manufacturers, wholesalers/distributors, and public hospital pharmacies). The technology-organisation-environment (TOE) framework, developed by Tornatzky & Fleischer (1990), was adopted as the conceptual framework for conducting this research. The TOE framework has been confirmed by literature as the most commonly used theoretical lens for new technology adoption studies (Lai et al., 2018). The TOE framework has been applied in different BDA adoption research in the context of supply chain management to investigate the determinants that can motivate or hinder organisations to adopt BDA (Agrawal, 2015; Chen et al., 2015; Lai et al., 2018; Verma & Bhattacharyya, 2017; Verma & Chaurasia, 2019). The determinants influencing organisations to adopt BDA are not only limited to technological factors but also organisational and environmental factors need to be considered (Verma & Chaurasia, 2019). The TOE framework is categorised into technology, organisation, and environment contexts, but the indexes in these contexts vary slightly in different studies (Cao, Jones & Sheng, 2014). The findings identified the determinants of BDA adoption in Australian pharmaceutical entities based on the TOE framework which are mentioned below.

- Technology Context: 1) relative advantage, 2) technology compatibility, 3) data quality
- Organisation Context: 1) top management support, 2) organisational readiness
- Environment Context: 1) government policy and regulation, 2) trading partner pressure

These findings are supported by previous studies in the extant literature. For instance, Sun et al. (2018) reviewed papers on business intelligence and analytics published between 2009 and 2015 and identified 26 factors influencing organisations' intention to adopt BDA. Relative advantage is the most commonly cited factor in the literature, followed by organisational readiness (human resources and technology resources) and top management support. Trading partner pressure, regulatory environment, and compatibility ranked eighth, tenth, and 21st respectively from among

26 factors. Table 5.1 provides a profile of innovation adoption studies based on the TOE framework including BDA and other new technology adoption determinants which are consistent with the identified determinants in this study.

Table 5. 1 Examples of innovation adoption studies based on the TOE framework

ICT Innovation	Past Research	Determinants						
		Technology Context			Organisation Context		Environment Context	
		Relative Advantage	Compatibility	Data Quality	Top Management Support	Organisational Readiness	Government Policy and Regulation	Trading Partner Pressure
BDA	Verma & Chaurasia (2019)	✓	✓		✓	✓		✓
BDA	Lai et al. (2018)	✓		✓	✓	✓	✓	
BDA	Verma & Bhattacharyya (2017)		✓		✓	✓		✓
BDA	Agrawal (2015)	✓	✓			✓	✓	
BDA	Chen et al. (2015)	✓	✓		✓	✓		
Cloud Computing	Gangwar et al. (2015)	✓	✓		✓	✓		✓
Cloud Computing	Ahmad & Waheed (2015)	✓	✓		✓	✓	✓	✓
Cloud Computing	Alshamaila et al. (2013)	✓	✓		✓	✓		✓
Cloud Computing	Low, Chen & Wu (2011)	✓	✓		✓	✓		✓
E-commerce	Rahayu & Day (2015)	✓	✓			✓		✓
Enterprise Application	Ramdani et al. (2013)	✓	✓		✓	✓		
RFID	Bhattacharya & Wamba (2018)	✓	✓		✓	✓		✓
RFID	Wang, Wang, & Yang, (2010)	✓	✓		✓	✓		✓
ICT	Pudjianto & Zo (2009)		✓		✓	✓	✓	
E-business	Zhu et al. (2006)				✓	✓	✓	

5.2.1 Technology Context

In this research, technological determinants are comprised of 1) relative advantage, 2) technology compatibility, and 3) data quality, which are discussed below.

5.2.1.1 Relative Advantage

Relative advantage is defined as the expected operational and strategic benefits which are obtained from the use of a novel technology (Venkatesh & Bala, 2012), for example BDA adoption in this study. The findings of this research indicate that relative advantage is one of the most significant factors for BDA adoption intention. This study is in line with previous studies in the literature that have used TOE framework to investigate the determinants of BDA adoption (Chen et al., 2015; Lai et al., 2018; Ramanathan, Philpott, Duan, & Cao, 2017; Verma & Chaurasia, 2019). The findings reveal that there is a positive relationship between the relative advantage of BDA and the intention to adopt this tool. This is strongly supported by the literature. For instance, Verma and Chaurasia (2019) argue that the relative advantage is a determining factor that motivates organisations to adopt BDA because organisational leaders are convinced to adopt new technology only when they perceive that the new technology can provide them with business benefits and competitive advantage. Also, Chen et al. (2015) state that supply chain activities are extensively data-driven with complex decision processes. Therefore, if managers understand the potential benefits that BDA can bring to their organisations, they are definitely more likely to adopt BDA to leverage its advantages.

The analysis of interviews demonstrates that BDA can assist Australian pharmaceutical entities (manufacturers, wholesalers/distributors, and public hospital pharmacies) in different ways. The

informants also indicated that BDA could enable supply chain entities to access free flow of data more efficiently in real-time, which would provide more visibility over stock levels and consumption rates along supply chain. Improved visibility allows suppliers to predict the possible replenishment requests from their consumers and assist them to be prepared in advance. The informants further indicated that as market demands fluctuate, improved visibility enables manufacturers to make timely adjustments to their demand forecasting in order to have accurate demand forecasting and mitigate the chances of drug shortages (See Section 4.3.1). The informants also stated that accurate demand forecasting by manufacturers can reduce the need to overstock drugs in hospital pharmacies and wholesalers to safeguard themselves against drug shortage. As a result, reduced inventory levels in hospital pharmacies and wholesalers lead to greater costs saving as fewer staff members are required to handle drug shortages. Furthermore, decisions can be made more precisely and quickly, saving partners' time and costs.

The above-mentioned findings are corroborated by literature as well. For example, Chen et al. (2015) argue that BDA improves the coordination of supply chain activities and data sharing among supply chain partners which, in turn, reduces operational costs, tailors customer service, and improves supply chain practices. In a similar vein, other studies confirm that access to real-time data through BDA can improve business operations and reduce associated costs (Miller & Mork, 2013; Verma & Chaurasia, 2019). Real-time data can improve decision-making and efficiency, lower labour costs, and even decrease lead-time (Agrawal, 2015; Miller & Mork, 2013). BDA can also integrate internal and external data in order to analyse the changes and make accurate predictions about the industry (Gunasekaran et al., 2017; Lai et al., 2018) and enable organisations to have more accurate demand forecasting (Verma & Chaurasia, 2019). The aforementioned discussion leads to the following proposition:

Proposition 1: Relative advantage of BDA positively correlates with the intention to adopt BDA by Australian pharmaceutical entities.

5.2.1.2 Technology Compatibility

Technology compatibility is presented by interviewees as another technological enabler which motivates decision-makers to adopt BDA. Compatibility refers to "the degree to which the innovation is perceived as consistent with the existing values, past experiences, and needs of the potential adopter" (Rogers, 2003, p. 240). If organisations find BDA compatible and in line with their existing organisational values, needs, and work practices, they are more intent on adopting and using BDA in their supply chain activities. In the current study, manufacturers and wholesalers confirmed that BDA adoption is consistent with their organisational needs and values and that their organisations are heading towards BDA adoption soon (See Section 4.2.1.2). They further stated that BDA adoption is compatible with their technological needs to gain more benefits from analysing the siloed data along their supply chain. This result is consistent with the literature that states the technological compatibility can positively contribute to BDA adoption intention (Agrawal, 2015; Chen et al., 2015; Verma & Bhattacharyya, 2017). Technological compatibility was also investigated earlier in other technological innovations adoption studies such as RFID adoption (Wang et al., 2010), cloud computing adoption (Alshamaila et al., 2013), and adoption by SMEs (Ramdani et al., 2013). The findings of this research disclose that technology compatibility is just supported by the manufacturers and wholesalers as a significant factor influencing their decision to adopt BDA. The discussion above leads to the following proposition:

Proposition 2: Technology compatibility positively correlates with the intention to adopt BDA by Australian manufacturers and wholesalers.

5.2.1.3 Data Quality

Supply chain operations traditionally emphasises physical flow and financial flow and information flow. Although, information flow was inherent to the supply chain operations, it was less emphasised in most of the cases (Rai, Patnayakuni, & Seth, 2006). However, today's supply chain managers are increasingly dependent on data to improve their visibility over their organisations' operations and business decisions (Hazen, et. al, 2014). It should be noted that if the quality of data is poor, the data is deemed useless and can even mislead organisations' business decisions (Warth, Kaiser, & Kügler, 2011) which results in both tangible and intangible losses for organisations (Batini, Cappiello, Francalanci, & Maurino, 2009). It has been estimated that poor data costs billions of dollars for U.S. businesses per year (Dey & Kumar, 2010) and also reduces customers' satisfaction (Batini, et. al, 2009).

Data quality refers to the degree to which data is accessible, accurate, complete, consistent in format, and timely in order to be shared among supply chain entities to enable managers to make informed decisions (Hazen, et. al, 2014; Kwon et al., 2014). The findings of this research indicate that data quality is a significant determinant which facilitates the adoption of BDA in Australian pharmaceutical entities (See Section 4.2.1.3). This result is consistent with the study conducted by Lai et al. (2018) who argue that organisations with a high level of data quality are more likely to adopt BDA to achieve success. Based on a survey conducted on 3,000 top managers across approximately 30 industries in 100 countries, one out of five respondents specified that data quality was a primary impediment that hinders BDA adoption (LaValle et al., 2011).

The existing literature also indicates that the successful implementation of BDA relies heavily on data sharing among supply chain partners (Arunachalam et al., 2018; Dutta & Bose, 2015). It is

also important for organisations to access accurate and complete data in a timely manner (Katal, Wazid, & Goudar, 2013). In general, the pharmaceutical healthcare industry suffers from a lack of data sharing among its supply chain partners, where little to no data is shared (Eurich, Oertel, & Boutellier, 2010; Gunawan & Simatupang 2014). Gavirneni, Kapuscinski, and Tayur (1999) identified three types of data-sharing: no data-sharing, partial data-sharing, and full data-sharing. The interview findings reveal that despite partial data sharing between manufacturers and wholesalers, there is no direct data sharing between the manufacturers and hospital pharmacies. Instead, the manufacturers purchase hospital pharmacies' data through companies such as IQVIA. However, this data is out-of-date and cannot provide an accurate picture of current market needs. Consequently, the data is neither accurate nor in real-time which renders it difficult for the manufacturers to rely on for a precise demand forecasting. The lack of collaboration and data sharing among pharmaceutical supply chain partners in Australia is further compounded by a fragmented system (Australian Government Productivity Commission, 2015). Additionally, some of the healthcare data is in non-standardised formats, such as orders placed via fax, which cannot be used for data analytics, thus giving rise to data silos (CSIRO, 2015; Productivity Commission 2017). The issue of delayed data and inaccurate demand forecasts in supply chain organisations is verified in the literature (Zhao, Xie, & Zhang, 2002), especially in the pharmaceutical industry where there are intermediary entities (wholesalers) between manufacturers and the hospitals (Gunawan & Simatupang, 2014).

Another reason for the lack of data sharing has to do with the ultimate business goal congruence of organisations in the supply chain. The commitment to and intensity of data sharing depends on factors such as 'inter-organisational connection' and 'goal congruence' (Samaddar, Nargundkar, & Daley, 2006). The findings confirm that public hospitals are funded by the government and thus

they strive towards quality service rather than financial profits. On the other hand, manufacturers are multinational conglomerate corporates whose ultimate goal is to design new products and increase their business profits. Therefore, the absence of "goal congruence" is attributed to the lack of data sharing. The findings of this research indicate that the pharmaceutical manufacturers are reluctant to share data with each other. Although, the data can provide a stronger competitive edge for manufacturers, the fear of losing markets and financial benefits to competitors is a common factor in the lack of data-sharing among supply chain entities (Kembro, Selviaridis, & Näslund, 2014).

The lack of data sharing also plagues public hospitals as confirmed by the informants in this study. The unwillingness of public hospitals to share data is closely associated with their funding level. The level of funding in public hospitals is performance-driven. Hospitals, therefore, abstain from sharing their data as they can be deemed high-performing or low-performing in comparison with other hospitals. This can result in the allocation of higher or lower levels of funding (See Section 4.2.1.3). This is corroborated by reports from Australian policy and government organisations which have similarly identified the absence of a systematic data sharing mechanism in Australian hospitals (Productivity Commission, 2015; McKell Institute 2016). In a similar vein, the Australian Institute of Health and Welfare's report (2018a, p. 32) specifies a lack of data sharing and the resultant data silos inhibit the use of big data in the Australian healthcare system. Data silos do not allow the data to be integrated and turned into 'smart' and insightful data. The discussion above leads to the following proposition:

Proposition 3: Data quality positively correlates with the intention to adopt BDA by Australian pharmaceutical entities.

5.2.2 Organisation Context

In this research organisational determinants that are investigated comprised of 1) top management support and 2) organisational readiness which are discussed below.

5.2.2.1 Top Management Support

Based on the TOE framework, top management support refers to the degree to which top managers understand, appreciate, and support the adoption of a new technology such as BDA (Chen et al., 2015). Indeed, when top managers perceive the potential benefits that the adoption of BDA can bring to their organisations and their supply chain operations, they have greater intent to move toward BDA adoption (Chen et al., 2015; Lai et al., 2018). The adoption of BDA requires adequate resources for implementation and operations including financial support, skilled employees, and robust IT infrastructure (Lai et al., 2018). Therefore, it is essential that top managers provide sufficient resources for the adoption of BDA and also create a supportive atmosphere to cope with the difficulties and complexities they encounter in adopting BDA in their organisations (Verma & Bhattacharyya, 2017).

The findings of this research demonstrate that Australian pharmaceutical entities highly rely on their top managers to provide initial investment in improving organisational IT infrastructure (software and hardware) as the first step toward BDA adoption (See Section 4.2.2.1). Furthermore, to fully reap the benefits of BDA, organisations require data scientists/skilled analytics professionals who are also experts in domain knowledge including supply chain management and healthcare. Therefore, it is imperative that top managers recruit data scientists and/or provide training programs for their current staff to upgrade their capability and knowledge. Apart from robust IT infrastructure and professional employees, manufacturers stated that they need to

purchase data from data warehousing companies for which they receive top management support as well. As a result, informants strongly confirmed that top management support plays a significant role in motivating an organisation to adopt BDA which is consistent with the literature.

Previous studies verify that top management support positively impacts the likelihood of new technology adoption in general (Alshamaila et al., 2013; Gangwar et al., 2015; Ramdani et al., 2013) and BDA adoption in particular (Chen et al., 2015; Lai et al., 2018; Verma & Bhattacharyya, 2017; Verma & Chaurasia, 2019). It is argued that without top management support, the likelihood of adopting new technology significantly decreases (Alshamaila et al., 2013). The discussion above leads to the following proposition:

Proposition 4: Top management support positively correlates with the intention to adopt BDA by Australian pharmaceutical entities.

5.2.2.2 Organisational Readiness

Organisational readiness is defined as "the availability of the necessary organisational resources for using BDA" (Chen et al., 2015, p. 18). These resources consist of both robust IT infrastructure and professional data analytics employees (Agrawal, 2015). Organisations require robust IT infrastructure and skilled data scientists to capture, store, analyse, and visualise the huge amount of data generated from various sources in different types. Organisational readiness is identified by the informants in this study as one of the significant determinants which motivate pharmaceutical entities to adopt BDA. The findings of current research are in accordance with previous studies which emphasise the significant role that organisational readiness plays in the intention for innovation adoption (Hsu et al., 2014; Low et al., 2011; Ramdani et al., 2013; Wang et al., 2010) and particularly in BDA adoption context (Chen et al., 2015; Verma & Chaurasia, 2019).

As big data refers to a high volume of data generated at a high rate from various sources and in different formats, traditional techniques are unable to handle it in order to support decision-making. Therefore, new techniques and computing approaches need to be implemented (Nasser & Tariq, 2015; Wang et al., 2016b). The analysis of findings reveals that Australian pharmaceutical entities have different IT infrastructure maturity levels. The robustness of IT infrastructure varies considerably along the supply chain with manufacturers on the top and hospital pharmacies at the bottom (See Section 4.2.2.2). The varying IT infrastructure maturity level renders collaboration and data sharing among supply chain partners cumbersome. In a similar vein, it is argued that different levels of data analytics infrastructure among supply chain partners disrupt data sharing in real-time (Arunachalam et al., 2018) and hamper the visibility of an end-to-end supply chain (Kache & Seuring, 2017). Consequently, insufficient IT infrastructure is one of the most significant inhibitors of the adoption of BDA (Kache & Seuring, 2017). Therefore, IT infrastructure in Australian pharmaceutical entities, especially hospital pharmacies, needs to be upgraded to have effective data sharing capability and, thus, leverage the benefits of BDA.

Successful implementation of BDA also relies on the availability of data scientists/analytics professionals (Arunachalam et al., 2018; Schoenherr & Speier-Pero, 2015; Sivarajah, Kamal, Irani, & Weerakkody, 2017). BDA is a novel technology that requires complex mechanisms for managing an incredibly large and diverse volume of data that is generated from myriad sources at a very rapid rate (Verma & Chaurasia, 2019). Therefore, BDA adoption requires an advanced level of analytics skills for data analysis (Katal et al., 2013). Indeed, organisations require data scientists/analytics professionals who are adept in statistical modeling and BDA to be able to understand, analyse, and interpret data patterns in order to yield valuable results (Kache & Seuring, 2017). Hsu, Ray, and Li-Hsieh (2014) argue that organisations with higher IT infrastructure and

professional data analytics are more likely to adopt new technology since they are more acquainted with the use of new information technologies and have the appropriate knowledge to adopt new technology.

In a similar vein, the informants in this study highlighted the importance of skilled data scientists/analytics professionals as a determinant of BDA adoption intention (See Section 4.2.2.2). They also stated that they need professional data scientists/analytics professionals who are proficient in supply chain and healthcare domain. They indicated that the recruitment of qualified data scientists/analytics professionals with domain knowledge is a real challenge and hinders them from adopting BDA. The interview findings further highlight the significance of BDA knowledge in conjunction with domain knowledge either in supply chain or healthcare. Similarly, the importance of the amalgamation of both data scientists/analytics professionals and domain knowledge is accentuated in the literature (Waller & Fawcett, 2013). Verma and Chaurasia (2019) argue that difficulty in recruiting data scientists with domain knowledge might be a critical inhibitor of BDA adoption in organisations. The paucity of BDA scientists/analytics professionals who are experts in supply chain is regarded as a significant challenge (Richey, Morgan, Lindsey-Hall, & Adams, 2016), a fact that was acknowledged by the informants in this study.

To further compound the issue of human resource shortage, it is estimated that BDA services will grow at 23% through 2020 (cited in Lee, 2017) which further burdens organisations in terms of their analytics capabilities. To illustrate the severity of skills shortage impact, a McKinsey report estimated that by 2018 the United States would encounter a shortage of 160,000 professionals with data analytics skills as well as 1.5 million managers who would be able to make decisions informed by data analytics (cited in Hilbert, 2016). In a similar vein, a survey conducted involving more than 400 senior executives revealed that organisations will require 33% additional big data

professionals by 2020. However, despite having big data technological capabilities, more than 65% of these organisations struggle to source appropriately skilled analytics professionals to yield meaningful insights from big data (cited in Lee, 2017). The difficulty in applying skilled analytics can impact organisations in myriad ways such as increased errors in records and data entry, loss of valuable data, and loss of business benefits (Alharthi, Krotov, & Bowman, 2017). A recent report by the World Economic Forum about future technologies in healthcare cites BDA as one of the game changers, but also notes that the effective implementation of this technology would be impossible without skilled analytics professionals (World Economic Forum, 2019).

In the context of the Australian healthcare sector, the McKell Institute, a not-for-profit public policy organisation based in New South Wales, organised a roundtable with a diverse cohort of healthcare stakeholders in 2015 to discuss the adoption of BDA in the healthcare sector. The participants described recruiting people with knowledge in statistics, data science, analytics, and interpretive skills as one of their main challenges which hinders them from adopting BDA (McKell, 2016). Australia has also recognised data management and analytics as one of the key digital skills shortages (Ministry of Industry, Science and Technology, 2018). In response, the Australian government's data strategy for 2018-20 emphasises the significance of enhancing people's 'data skills and capabilities' from foundational skills to advanced data analytics, modeling, and predictive analytics. The strategy also acknowledges the value of fostering domain knowledge jointly with data analytics through learning and development programs (Department of Industry, Innovation, and Science, 2018, p.17).

Furthermore, in order to alleviate the profound effects of analytics skills shortage, both education providers and adopter organisations play a crucial role. Lack of proper training for data analysts is deemed to be an inhibitor in the adoption of BDA (Noormohammad, et. al, 2010). As BDA is still

an emerging technology in its inchoate state, organisations need to provide training opportunities for their employees to upskill and enhance their capabilities (Lee, 2017). Similarly, universities should also launch BDA programs to create a viable workforce to meet future demands (Katal et al., 2013). The discussion above leads to the following proposition:

Proposition 5: Organisational readiness positively correlates with the intention to adopt BDA by Australian pharmaceutical entities.

5.2.3 Environmental Context

Based on the TOE framework, external pressure for adopting new technology are divided into three categories: 1) government policy and regulation, 2) trading partner pressure, and 3) competitive pressure, which are defined below:

- Government policy and regulation refers to the "governmental support [that] requires a firm to adopt a new technology";
- Trading partner pressure refers to the "pressure from upstream and downstream business partners which influences a firm to adopt new technology in order to maintain cooperative relationships";
- Competitive pressure refers to the "pressure from business competitors that forces a firm to adopt new technology for the sake of maintaining competitiveness" (Hsu et al., 2014, p. 477).

The findings of this study reveal that none of the Australian pharmaceutical entities has adopted BDA yet; although competitive pressure is not indicated by the informants in the current research,

the role of government policy and regulation, in conjunction with trading partner pressure in BDA adoption, have been identified. The details are discussed below.

5.2.3.1 Government Policy and Regulation

As the Australian pharmaceutical healthcare industry is heavily regulated, the support of government policy and regulation can facilitate the adoption of new technologies such as BDA. This result is consistent with the study conducted by Lai et al. (2018) who argue that if the government demands organisational top managers to adopt new technology such as BDA, they are more likely to respond to government policies and regulations. Zhu et al. (2006) argue that governments can motivate organisations to adopt new technology by setting supportive policies and regulations and/or offering technical support, training, and funding for technology implementation. They also highlight the significant role of the regulatory environment on e-business adoption through enacting policies and regulations that facilitate the process. Conversely, a restrictive government regulatory environment hinders the adoption of new technologies (Zhu & Kraemer, 2005). The findings reveal that the Australian pharmaceutical healthcare industry is rigidly regulated in order to maintain high standards and optimum quality (See Section 4.2.3.1). However, the Australian government's regulations and compliance requirements impede pharmaceutical healthcare entities from adopting BDA and limit their access to data, hence slowing the process of adopting BDA.

The evidence in industry reports corroborates with the finding of this research as to the fact that the Australian strict regulatory framework poses a challenge to the adoption of new technologies. This can hold back the timely adoption of innovations, reduce cooperation among government and pharmaceutical healthcare entities, and limit data sharing among supply chain partners. A research

report, conducted by PricewaterhouseCoopers (2015, p. 6-7) on the challenges of Australian pharmaceutical industry concluded that increasing regulations and compliance requirements was responsible for the "lack of collaboration between [pharmaceutical] industry and government." In a similar fashion, a CSIRO report (2017) into the Australian pharmaceutical industry echoes the concern that the stringent pharmaceutical regulations can curb access to new technologies. In response, the report calls for a 'modernisation' in Australia's regulatory practices to facilitate the uptake of new technologies. Therefore, the support of the government in a rigidly regulated industry such as the pharmaceutical industry is highly imperative to adopt new technology. The discussion above leads to the following proposition:

Proposition 6: Government policies and regulations positively correlate with the intention to adopt BDA by Australian pharmaceutical entities.

5.2.3.2 Trading Partner Pressure

The analysis of interview data confirms that pressure from trading partners can motivate manufacturers to upgrade their IT infrastructure/capability and adopt BDA to maintain their collaboration and cooperation with them (See Section 4.2.3.2). This result is aligned with the previous studies such as Verma and Chaurasia (2019) who argue that trading partner pressure can have a positive effect on BDA adoption in order to establish perfect trading partner relationships. Similarly, Verma and Bhattacharyya (2017) confirm that managers might be more likely to adopt BDA if they receive requests from their trading partners to this effect or if their trading partners have already adopted BDA. The literature also testifies to the fact that pressure from trading partners can positively influence innovation adoption (Alshamaila et al., 2013; Low et al., 2011;

Musawa & Wahab, 2012; Wang et al., 2010). The aforementioned discussion leads to the following proposition:

Proposition 7: Trading partner pressure positively correlates with the intention to adopt BDA by Australian pharmaceutical manufacturers.

5.3 Potential Impact of Big Data Analytics Adoption on Decision-making across SCOR Processes

This section discusses the potential impact of BDA adoption on SCOR processes based on the interview findings. The findings address the following research question.

RQ_2: How does BDA improve decision-making across supply chain processes (SCOR processes: plan, source, make, deliver, and return) in the Australian pharmaceutical supply chain?

Based on the existing literature, BDA can improve decisions in each SCOR process as demonstrated in Figure 5.1. Each process is discussed separately in the following section.

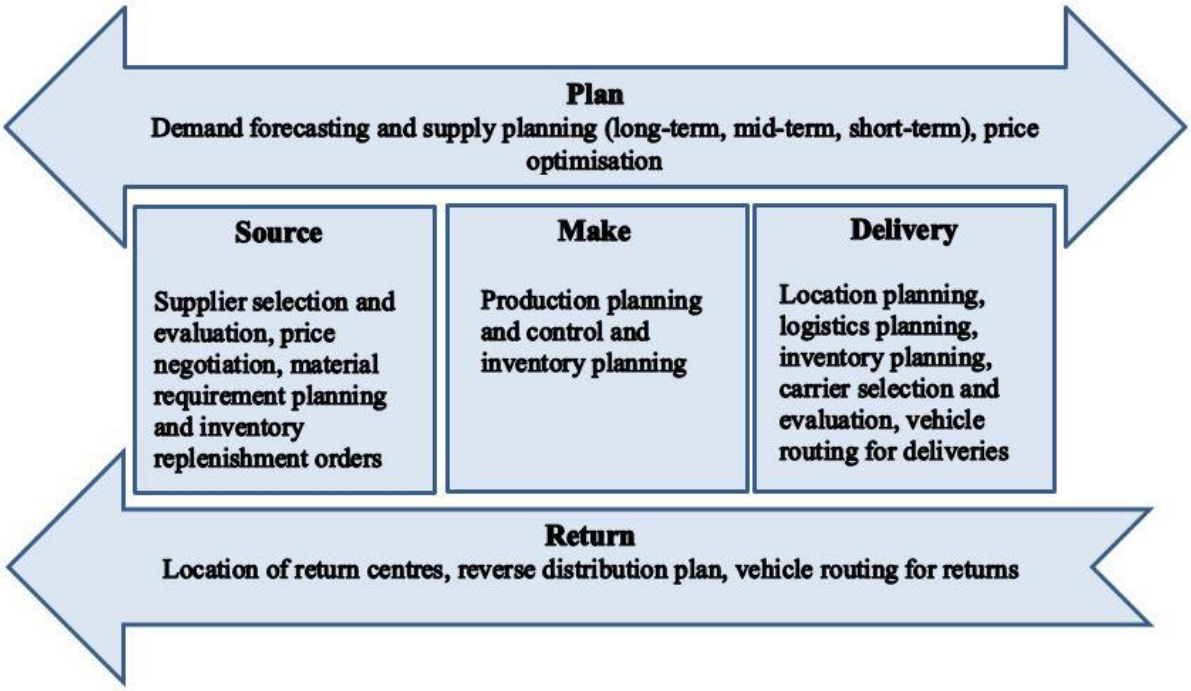

Figure 5. 1 Decision-making in SCOR processes

Source: Adapted from Herden (2017)

5.3.1 Plan

The first SCOR process is planning which was discussed by the informants during the interviews. As demonstrated in Chapter 4.3, all three pharmaceutical entities, including manufacturers, wholesalers/distributors, and hospital pharmacies, rely on historical data as their main source of information for planning. Manufacturers and wholesalers/distributors refer to their inventory systems to view their sales, predict their demand forecast, and make necessary adjustments based on market changes. Hospital pharmacies also follow the same process based on their consumption. Although, the use of historical sales data for demand forecast is quite common in organisations (Ganeshan & Sanders, 2018), it is likely to predict a less reliable demand forecast. The results revealed some unanticipated circumstances such as disease outbreaks or manufacturers' loss of

drug batches due to quality issues or logistics issues which can increase demand for certain drugs. Therefore, when demand exceeds forecasts based on historical data, drug shortages occur. The results also confirm that drug shortage is a recurring issue in the Australian pharmaceutical supply chain (See Section 4.3.1). Similarly, literature supports the fact that demand forecasts informed by historical data cannot be very accurate as unexpected circumstances such as stock-outs can disrupt the whole supply chain (Ganeshan & Sanders, 2018). Therefore, a collaborative forecast incorporating the partners' participation will elevate the demand inaccuracies.

Furthermore, a cross-case analysis of results reveals that drug shortage has been a major issue across the Australian pharmaceutical supply chain. This problem is experienced by hospitals and wholesalers on daily basis (See Section 4.3.1). Some drug shortages are only short-term where the hospitals cope through alternative methods. However, the long-term shortages can have adverse effects on patients and incur high costs on hospitals. This is corroborated by a survey, conducted by the SHPA on April 4th, 2017, that identified drug shortages as a seminal problem for both public and private hospitals across Australia. The survey respondents consisted of 280 health service providers of different sizes from a range of sectors including public, private, and non-for-profit. The survey revealed that 1,577 drug shortage entries, of which 365 were commercial products, were registered on one single day only. The actual number of entries was most likely higher than recorded as the survey tool allowed the respondents to register a maximum of 30 items only, while some participants had more shortage items to record.

The current findings of the study demonstrate that hospitals and wholesalers either increase their inventory level to safeguard against the effects of drug shortages or designate some staff members to manage drug constraints due to the frequency of the issue. Higher inventory levels or designated staff or both can increase organisations' costs. Hospitals also resort to procuring alternative drugs

if possible. However, alternative drugs are usually sourced from overseas; therefore, they are not subsidised by the PBS—hence the exorbitant costs for hospitals.

The study findings are supported by SHPA's report (2017). SHPA's survey indicates that drug shortages negatively impact patient care, employee resourcing, and the pharmacy budget. Approximately one-third of the measures implemented to tackle drug shortages adversely affected patients. These measures included prescription of alternative but less effective drugs, or even change in the drugs' route of administration. Changing drug prescriptions to less-effective drugs generates more complications such as longer recovery times which entail longer stays in hospitals and increased healthcare costs. Resorting to alternative drugs or a change in the route of administration can also increase the risk of further side effects. More than half of the survey respondents confirmed that the actions taken to alleviate drug shortages increased their costs through buying expensive alternatives and staff resourcing (SHPA, 2017).

The informants in this research believe that BDA adoption can be highly conducive to the planning process as it makes a large volume of insightful data available for supply chain entities. The data enables entities to have improved visibility over the whole supply chain and also the market; it enables entities to monitor consumption and the demand rate in real-time, via accurate data. Supply chain entities, especially manufacturers, can also monitor fluctuations and changes more efficiently and make accurate demand forecasts. This can also improve and expedite supply chain decision-making in a more efficient manner. BDA also enables entities to make timely adjustments to their forecasts which can empower entities to react more quickly and effectively in case disruptions, such as drug shortages, occur in the market. Supply chain entities can also save more costs as BDA enables them to manage their staff and resources more effectively by not having to overstock their warehouses in anticipation of likely drug shortages which can incur unnecessary

costs. Therefore, BDA is an efficient way of decreasing the chances of drug shortage occurrence as well as saving costs.

The findings of this research are consistent with the extant literature regarding BDA advantages in planning. Data analytics' significant contribution in supply chain is attributed to forecasting demands and monitoring the market. (Ganeshan & Sanders, 2018; Trkman et al. 2010). Demand forecasting that is informed by BDA is capable of yielding insights about future trends and enables supply chain entities to predict the potential uncertainties and issues to make the right decisions (Biswas & Sen, 2016). The future supply chain will generate enormous volumes of data which can be leveraged through BDA to offer meaningful insights and improve decision-making (Biswas & Sen, 2016). Effective decisions informed by BDA rely on complete and accurate data that is made available in real time (Meredig, 2017). This requires increased collaboration and data sharing among supply chain entities to improve visibility over consumption rates and the demand patterns of partners and allow them to make coordinated decisions in real time to have accurate demand forecasts (Ganeshan & Sanders, 2018; Saha & Jha, 2018). This capability empowers supply chain entities to tackle uncertainties in the market and increase visibility and streamline operations in both the upstream and downstream of the supply chain (Gunasekaran et al. 2015; Zhu, Song, Cegielski, & Lee, 2017). The main advantage of BDA in the planning process focuses on improving decision-making through enhanced visibility (McAfee, Brynjolfsson, Davenport, Patil, & Barton, 2012; Zhu et al., 2017). A recent report indicates that decisions informed by BDA can expedite demand replenishment by 10 per cent and improve supply chain efficiency by 10 per cent to 36 per cent (Saha & Jha, 2018). Indeed, BDA capability can enable supply chain entities to be more responsive to market changes and address market disruptions or issues such as disease outbreaks more quickly (Ganeshan & Sanders, 2018).

Proposition 8: BDA adoption positively improves decisions in the planning process of Australian pharmaceutical entities.

5.3.2 Sources

BDA's contribution to the sourcing process lies in improving decisions regarding the evaluation and selection of key suppliers (Biswas & Sen, 2016; Herden, 2017; Raman, et. al., 2018; Souza, 2014; Zhu et al., 2017; Zhu et al., 2018). BDA can integrate useful information about suppliers' past and current performance and yield insights about their future performance (Zhu, et. al., 2017). The information can be evaluated both qualitatively and quantitatively in order to provide a detailed overview of a given supplier's performance and offer transparency in the upstream of supply chain (Zhu, et. al., 2018). For example, BDA can evaluate the supplier's performance based on product quality, on-time delivery, cost, reliability, and flexibility (Souza, 2014). The capability of BDA to assess these criteria and provide future indications of a supplier's performance can improve decision-making regarding the selection of suppliers. (Zhu, et. al, 2018).

In the context of this research, the informants also pointed out similar criteria for selecting a supplier (See Section 4.3.2). However, they did not identify the advantages of BDA in their sourcing process. One reason can be attributed to the tenders the HPV holds for generic drugs. Hospital pharmacies purchase their drugs from suppliers which have won the HPV tenders. Therefore, the hospital pharmacies and wholesalers simply prefer to select suppliers through the HPV. Regarding originator drugs, there are only a handful of manufacturers that produce these drugs. Therefore, hospital pharmacies and wholesalers do not have many options to select from. Another reason relates to the limited number of pharmaceutical wholesalers in Australia which

does not offer hospitals more choices. BDA, however, can be helpful when there are myriad suppliers (Souza, 2014) which renders selection decisions difficult.

Proposition 9: BDA adoption may not improve decisions in the sourcing process of Australian pharmaceutical entities.

5.3.3 Make

BDA can offer benefits in the make process as well (Biswas & Sen, 2016; Herden, 2017; Raman, et. al., 2018; Souza, 2014; Trkman, et. al., 2010). The main advantages pertain to production processes and machinery in factories or manufacturing facilities where products are manufactured. Production facilities usually utilise high-tech equipment which generates huge amounts of data that can be analysed through BDA to offer insights about machinery performance, possible future production issues, or equipment faults (Auschitzky et al., 2014). It can also enable the predictive maintenance of factory equipment to identify faults before they actually occur (Zhu, et. al, 2017; Zhu, et. al, 2018). In the context of this research, the informants did not identify the advantages of BDA in the make process. This result can be associated with the informants' lack of knowledge and unfamiliarity with BDA in the Australian pharmaceutical supply chain as this phenomenon is not yet utilised and organisations are beginning to become more cognizant of BDA advantages. More importantly, the informants' focus from manufacturers was mainly directed towards planning, sourcing, and distribution of pharmaceutical products rather than production.

Proposition 10: BDA adoption may not improve decisions in the making process of Australian pharmaceutical entities.

5.3.4 Deliver

BDA can help supply chain entities in the delivery process to save costs and improve customer satisfaction (Chae, 2009; Raman, et. al., 2018). The delivery process is often a complex one that generates large volumes of logistics data about geographical locations, delivery performance, route selection, the fuel efficiency of transport fleets, etc. Through BDA, the generated data can be integrated and analysed to yield useful insights about logistics issues and processes such as fuel consumption, route selection, and fleet performance, thus offering improved visibility about logistics operations (Hopkins & Hawking, 2018; Zhu, et. al., 2018). BDA can improve decision-making in this process to enable entities to deliver drugs at the right location and at the right time in a quick and affordable manner by techniques such as route or fuel optimisation. The findings of this research confirm that manufacturers identified BDA adoption advantages mainly in their delivery process (See Section 4.3.4). The informants stated that BDA can yield information about suitable geographical locations and target audience for their products and also save costs through improving decision-making about distribution with regards to delivery modes and geographic location of patients or hospital pharmacies.

Proposition 11: BDA adoption positively improves decisions in the delivery process of Australian pharmaceutical manufacturers.

5.3.5 Return

BDA can also yield advantages in the return process (Herden, 2017; Raman, et. al., 2018; Souza, 2014). The emerging technologies, in combination with ICT, generate and store information that can be analysed through BDA to offer insights into better inventory management and cost reduction. This can be especially effective for identifying products that are about to be obsolete

and discarded that incur wastage costs on organisations (Raman, et. al., 2018). In the context of the Australian pharmaceutical supply chain, the informants explicated that short-dated drugs that are not used by their expiry date are usually discarded, costing their organisations large sums of money (See Section 4.3.5). They confirmed the benefits that BDA can offer in the return process by helping them identify short-dated drugs before they reach expiry date and also identify areas where these drugs might be in higher demand so that they can be dispatched and used in those areas rather than being discarded. This practice can improve inventory management by minimising stock wastage and related costs.

Proposition 12: BDA adoption positively improves decisions in the return process of Australian pharmaceutical entities.

Table 5.2 summarises the propositions developed through analysing interviews and investigating the extant literature.

Table 5. 2 Research Questions and Associated Propositions

Research Questions	Propositions
RQ_1: Determinants of BDA Adoption	Proposition 1: Relative advantage of BDA positively correlates with the intention to adopt BDA by the Australian pharmaceutical entities.
	Proposition 2: Technology compatibility positively correlates with the intention to adopt BDA by the Australian manufacturers and wholesalers.
	Proposition 3: Data quality positively correlates with the intention to adopt BDA by the Australian pharmaceutical entities.
	Proposition 4: Top management support positively correlates with the intention to adopt BDA by the Australian pharmaceutical entities.
	Proposition 5: Organisational readiness positively correlates with the intention to adopt BDA by the Australian pharmaceutical entities.
	Proposition 6: Government policies and regulations positively correlate with the intention to adopt BDA by the Australian pharmaceutical entities.
	Proposition 7: Trading partner pressure positively correlates with the intention to adopt BDA by the Australian pharmaceutical manufacturers.
RQ_2: Effect of BDA on SCOR Processes	Proposition 8: BDA adoption positively improves decisions in the planning process of Australian pharmaceutical entities.
	Proposition 9: BDA adoption may not improve decisions in the sourcing process of Australian pharmaceutical entities.
	Proposition 10: BDA adoption may not improve decisions in the making process of Australian pharmaceutical entities.

	Proposition 11: BDA adoption positively improves decisions in the delivery process of Australian pharmaceutical manufacturers.
	Proposition 12: BDA adoption positively improves decisions in the return process of Australian pharmaceutical entities.

5.4 Revised Conceptual Framework

Figure 5.2 presents the revised conceptual framework based on the interview analysis and literature review presented in this chapter. Data quality is incorporated into the revised framework as a new dimension of BDA adoption intention. In the initial framework (See Figure 2.6), data quality was not included as it is not a commonly recurring determinant in the literature about the TOE framework. The findings revealed that in the context of the Australian pharmaceutical supply chain, data quality plays a significant role.

Every day pharmaceutical organisations face large volumes of both structured and unstructured data created at an accelerating rate. They are increasingly dependent on data quality to improve their visibility over their supply chain for a precise demand forecasting. This data can be classified into two categories: internal and external. From an internal data perspective, informants stated that data is available, accurate, complete, reliable, and timely to make informed decisions. However, this story is different from an external data perspective. The Australian Institute of Health and Welfare's report (2018a, p. 32) specifies a lack of data sharing and the resultant data silos inhibit the use of big data in the Australian healthcare system. Data silos do not allow the data to be integrated and turned into 'smart' and insightful data. Partial and fragmented data sharing among the Australian pharmaceutical supply chain results in drug shortages which was one of the main problems that unanimously pointed out by all the informants in this research. The informants

argued that data quality among supply chain partners can enhance accuracy of demand forecasting and decrease drug shortages.

In a similar vein, the existing literature also indicates that the successful implementation of BDA relies heavily on data sharing among supply chain partners (Arunachalam et al., 2018; Dutta & Bose, 2015). However, the pharmaceutical industry suffers from a lack of data sharing among its supply chain partners, where little to no data is shared (Eurich, Oertel, & Boutellier, 2010; Gunawan & Simatupang 2014). According to the literate review and this research findins, a high level of data quality positively correlates with BDA adoption intention in the context of pharmaceutical supply chain. Therefore, the conceptual framework revised based on the new determinants called “data quality”.

Recommendation: It is recommended, as agreed by the participants, that pharmaceutical organisations need to improve their collaboration mechanism with their supply chain partners to enhance data flow back-and-forth across the supply chain. Pharmaceutical entities can establish a common database which is accessible to all entities. This database can enhance transparency along the supply chain and help manufacturers to access real-time, accurate, and complete data. Therefore, they are able to improve their demand forecasts and reduce the rate of drug shortages.

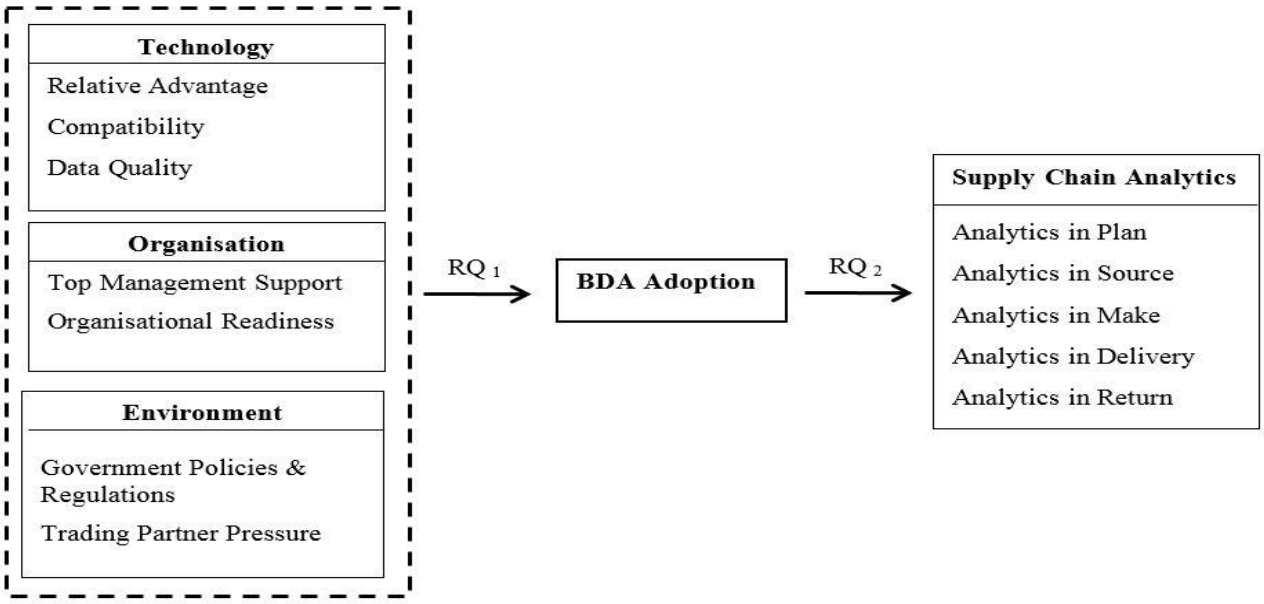

Figure 5. 2 Revised conceptual framework

5.5 Summary of Chapter

This chapter discussed the interview findings and compared the results with the extant literature to support and validate the findings. Drawing upon the TOE framework, the determinants of BDA adoption in Australian pharmaceutical entities (i.e. manufacturers, wholesalers/distributors, and hospital pharmacies) were compared with and supported by existing studies. The positive effects of BDA adoption on decision-making in each of the SCOR process (plan, source, make, deliver, and return) were also compared with and supported by the literature. Based on validated findings, a series of propositions were developed which are summarised in Table 5.2. The conceptual framework was also revised based on findings. Data quality as an important determinant of BDA adoption intention in the Australian pharmaceutical supply chain was incorporated into the framework. The theoretical and practical contribution of this research are discussed in the next chapter.

Chapter 6

Conclusion

6.1 Introduction

This chapter presents the summary of research findings, the theoretical and practical implications of this study, the limitations of this research, and recommendations for future research. The structure of this chapter is as follows: Section 6.2 summarises the research findings. Section 6.3 discusses the theoretical contribution of this study. Section 6.4 presents practical contribution and offers recommendations for each pharmaceutical supply chain entity and government as well. Section 6.5 discusses the limitations of this study and provides suggestions for future studies.

6.2 Summary of Research Findings

This study outlined two research objectives which were addressed through two research questions. The first objective **was "to investigate the determinants that can encourage or hinder the adoption of BDA in the Australian pharmaceutical supply chain context (i.e. manufacturers, wholesalers/distributors, and hospital pharmacies)." This** objective was covered through findings in Chapter 4 (See Section 4.2). This study utilised the technology-organisation-environment (TOE) framework to investigate the determinants of BDA adoption that fall into three contexts: technology, organisation, and environment.

Technology Context: This research highlighted the role of three technological factors namely, 1) relative advantage, 2) technological compatibility, and 3) data quality as important determinants

of BDA adoption. Informants' awareness of the operational and strategic relative advantages of BDA is one of the most significant adoption determinants which was vividly articulated by the Australian pharmaceutical entities. Technological compatibility was identified as another important determinant of BDA adoption for manufacturers and wholesalers/distributors as BDA adoption was consistent with their organisational and business needs and values. In this context, data quality is found to be equally significant. Currently, the poor data quality in the Australian pharmaceutical supply chain renders the demand forecast accuracy a challenging task. The lack of accessibility to real-time data can cause drug shortages— an important issue facing the Australian pharmaceutical supply chain. This study finds that BDA can help mitigate this issue if the partners share quality data in real-time.

Organisation Context: It encompasses two determinants: 1) top management support and 2) organisational readiness. Supply chain managers in manufacturing and some of the wholesalers/distributors are well aware of the advantages of BDA and provide the required support for BDA adoption. These supports can be in the form of investments in BDA adoption, the provision of training programs or recruitment of data analytics professionals. This research reveals that public hospital pharmacies do not receive management support for BDA adoption because the public hospitals are funded by the government where the service quality takes precedence over other factors. Moreover, pharmaceutical supply chain entities also need to upgrade their existing IT infrastructure to enable them to handle large volumes of data using BDA. Furthermore, the availability of skilled data analytics professionals, who also have proficient domain knowledge (supply chain and/or healthcare), is identified as a significant BDA adoption determinant. The organisational readiness of Australian pharmaceutical entities is found to be stronger at the level of manufacturers, but it declines further downstream towards hospital pharmacies.

Environment Context: This includes two determinants: 1) government policies and regulations and 2) trading partner pressure. As the pharmaceutical healthcare industry is heavily regulated, stringent government policies and regulations can hinder BDA adoption which is the current situation in Australia. However, a more harmonised and flexible regulatory framework can facilitate BDA adoption. Trading partner pressure was only identified as a factor by the manufacturers but not the wholesalers/distributors and hospital pharmacies.

The second objective was **"to understand how BDA adoption can improve decision-making in SCOR processes (i.e. plan, source, make, deliver, and return)."** The findings in Chapter 4 (See Section 4.3) highlighted the significant improvements that BDA adoption can offer to decision-making in SCOR processes.

Plan: The findings confirmed that BDA adoption can enable pharmaceutical entities to have improved visibility over the whole supply chain and also the market; it enables entities, especially manufacturers, to monitor consumption and the demand rate in real-time and make accurate demand forecasts which reduce drug shortages.

Source: Timely and precise decision-making can benefit from BDA adoption that allows the entities to source and manage their stocks more effectively. This can likely address the drug demand at hospitals and respond to unanticipated issues such as drug shortages.

Make: The informants did not identify the advantages of BDA in the make process which can be associated with the informants' lack of knowledge as this phenomenon is not yet utilised and organisations are beginning to become more cognizant of BDA advantages.

Delivery: The findings of this research confirmed that manufacturers identified BDA adoption advantages mainly in their delivery process. The informants stated that BDA can yield information about suitable geographical locations and target audience for their products and also save costs through improving decision-making about distribution with regards to delivery modes and geographic location of patients or hospital pharmacies.

Return: The application of BDA can be especially effective for identifying drugs that are about to be obsolete and identifying areas where these drugs might be in higher demand. This practice can improve inventory management by minimising stock wastage and related costs.

6.3 Theoretical Contribution

This thesis makes significant theoretical contributions to both supply chain management and BDA adoption literature. Although BDA adoption has been studied, this thesis is the first to investigate BDA adoption in the context of pharmaceutical supply chain. Earlier studies have focused on the clinical trials of medicines, but not their supply chain, which this dissertation sought to cover. The pharmaceutical supply chain is highly critical since the right medicines must reach the right patients at the right time, in good condition, and at the right price in order to save lives. A massive volume and variety of data from multiple sources is generated at a fast pace in pharmaceutical supply chain, which needs to be captured and analysed to realise its benefits in operational decisions. The pharmaceutical industry as such lags behind other industries in BDA adoption research. Therefore, this thesis addresses the gap in the literature by exploring the determinants of BDA adoption. This research proposes a conceptual framework by building upon the TOE framework which is a well-established theory for innovation adoption intention. This thesis

enriches the literature by identifying the technological, organisational, and environmental factors which influence the BDA adoption decision in the Australian pharmaceutical supply chain.

In addition to drawing upon the TOE framework, this research adds to the literature by considering data quality as a determining factor of innovation adoption. Data quality was not included as it is not a commonly recurring determinant in the literature about the TOE framework. However, the findings revealed that in the context of the Australian pharmaceutical supply chain, data quality plays a significant role. The findings of this study propose that organisations are more likely to adopt BDA when data is available, consistent, accurate, complete, and in real-time.

Another noteworthy contribution of this thesis is evaluating the positive influence of BDA on decision-making in each SCOR process (i.e. plan, source, make, deliver, and return) in the Australian pharmaceutical supply chain. In the existing literature (De Oliveira et al., 2012; Trkman et al., 2010; Zhu et al., 2018), the SCOR model is either examined as a single construct or only some processes of the SCOR model are selectively considered for investigation. However, this thesis considers all five processes of the SCOR model and examines each process separately as to how it benefits from BDA adoption.

Earlier studies (Agrawal, 2015; Chen et al., 2015; Lai et al., 2018; Verma & Chaurasia, 2019) on BDA adoption are mostly conducted quantitatively. As BDA is still new and pharmaceutical industry has not yet fully utilised its potential, this thesis employs an exploratory qualitative approach to empirically support and validate the proposed conceptual framework using supply chain as a unit of analysis. The review of the extant literature also indicates that previous studies neither focused on a specific industry nor considered the major actors in its supply chain in order to gain an in-depth view of the supply chain. Therefore, this research employs several methods of

data collection including face-to-face semi-structured interviews from the pharmaceutical partners (i.e. manufacturers, wholesalers/distributors, and public hospital pharmacies) along with site visits, participant observation, companies' documents, and the government reports. This has provided in-depth insights into the Australian pharmaceutical industry and add to the existing literature.

A further contribution of this research is the selection of the 'unit of analysis'. Given the complexity of supply chain, research in this area usually focuses on a single organisation rather than the supply chain as a whole (Defee et al., 2010). This research has focused on the pharmaceutical supply chain, comprised of manufacturers, wholesalers/distributors, and hospital pharmacies. Therefore, the investigation along the supply chain, as a unit of analysis, offers more in-depth insights in relation to BDA adoption than being done at a single organisation earlier. By analysing the perspectives of different entities across the supply chain network, this research presents a holistic picture of BDA adoption and its benefits on decision-making across SCOR processes.

6.4 Practical Contribution and Recommendation

- **The Implication for the Australian Pharmaceutical Entities**

This research has offered practical contributions to the Australian pharmaceutical sector where the manufacturers, wholesalers/distributors, and public hospital pharmacies are provided with the facilitators and inhibitors associated with BDA adoption. Underpinned by the TOE framework, this study analysed the current situation within technological, organisational, and environmental context to provide a full picture of the Australian pharmaceutical entities to make decisions about BDA adoption. Although, there are challenges for these entities to adopt BDA, the findings reveals

the potential of BDA in their businesses for better intelligence to improve decision-making through the application of data mining, statistical techniques, and forecasting.

It is evident that data quality is one of the significant determinants which motivates organisations to adopt BDA. Indeed, when data is accessible, accurate, consistent, and complete, organisations are more confident to adopt BDA. Also, the findings reveal a key issue that afflicts most of the Australian pharmaceutical entities suffer today is insufficient data-sharing and willingness to share data among the partners in a chain. This is where the BDA adoption is likely to suffer. The data is neither completely available nor sufficiently accurate for manufacturers to rely on. This poor data quality leads to inaccurate demand forecasts which might result in drug shortages.

Recommendation 1: It is recommended, as agreed by the participants, that organisational key decision-makers need to improve their collaboration mechanism with their supply chain partners to enhance data flow back-and-forth across the supply chain for their own benefits. Pharmaceutical entities can establish a common database which is accessible to all entities. This database can enhance transparency along the supply chain and help manufacturers to access real-time, accurate, and complete data. Therefore, they are able to improve their demand forecasts and reduce the rate of drug shortages.

This study targets top managers whose support is paramount in BDA adoption. The findings reveal that not all pharmaceutical entities receive top management support in BDA adoption in their organisations. For instance, manufacturers receive greater support from their top managers for initial investment in innovation adoption. Wholesalers are in the middle, but hospital pharmacies are not supported by hospital managers or the Australian governments.

Recommendation 2: It is recommended that top managers in all entities make appropriate funds available for the adoption and implementation of BDA. They need to create an environment where the employees are encouraged and motivated to effectively implement BDA in their organisations. Furthermore, they need to facilitate training programmes to upgrade their staff capability and recruit professional data scientists to successfully adopt BDA and seize the opportunities offered by this innovation.

The findings also provide insight into the potential benefits that BDA can offer in each SCOR process (i.e. plan, source, make, deliver, and return). This study evaluates the organisations' current supply chain processes and offers managers a better understanding of their own businesses and markets where they can make informed decisions about the supply chain of pharmaceutical products. These benefits include improved inventory management, efficient order fulfilment, human resource management, and quick responses to supply chain challenges. Analytics in the planning process supports pharmaceutical manufacturers and wholesalers in predicting and aggregating the demand and supply in their strategy in order to meet market requirements. Analytics in sourcing process will assist the entities to assess the suppliers' efficiency and select the preferred ones. Pharmaceutical manufacturers will be able to deliver their drugs in a cost-effective way using analytics in the delivery process. Analytics in the return process will help in the reverse flow of products from downstream to upstream using data-driven decisions.

Recommendation 3: It is recommended that pharmaceutical entities develop their capabilities such as upgrading their IT infrastructure and hiring data analytics professionals in order to adopt BDA to receive the significant benefits of this new technology.

- **The Implication for Government Regulatory Agencies**

The support of government policies and regulations can motivate organisations to adopt new technologies such as BDA. However, the findings of this research reveal that the Australian pharmaceutical industry is rigidly regulated which is likely to hold back the timely adoption of innovations. Therefore, pharmaceutical industry lags behind others in this regard. The findings also indicate that top managers are more intent on adopting BDA if the government demands it.

Recommendation 4: It is recommended that governments facilitate the adoption of BDA by setting supportive policies and regulations, promoting collaboration with pharmaceutical entities, and encouraging the data-sharing mechanism among supply chain partners.

6.5 Limitations and Future Research Directions

This thesis makes an original contribution to the existing literature in supply chain operations in the pharmaceutical healthcare industry and offers noteworthy theoretical and practical implications for both researchers and practitioners. However, the current thesis has some limitations which can offer opportunities for future research. The following points outline specific limitations as well as suggestions for further research.

- The entities in this thesis are limited to manufacturers and wholesalers/distributors in Victoria State and New South Wales State, as well as public hospital pharmacies located in Melbourne. To enhance the generalisability of the findings, future research can incorporate other supply chain partners such as government organisations (e.g. HPV and TGA), third party logistics providers, public and private hospitals across Australia.

- In the context of this research, there were only three organisations in which more than one informant was interviewed. In the remaining 12 organisations, only one informant was interviewed, mainly due to time constraints. Although the informants have had extensive experience in and knowledge of the pharmaceutical supply chain, the perceptions of one individual towards BDA adoption may not be representative of the whole organisation. Therefore, it is suggested that future research can include multiple informants from each organisation.

- This thesis relied on an inductive qualitative method through semi-structured interviews to build theories in the form of propositions. As BDA is emerging in the Australian pharmaceutical/healthcare industry, a qualitative approach was deemed conducive to gain an understanding of BDA determinants, how it can improve decision-making across SCOR processes and help build theories. The use of a single method, however, can limit its genreralisability. Therefore, employing a mixed-method approach (both qualitative and quantitative) in future research is recommended. This is in line with previous suggestions to incorporate more organisations and informants as the use of surveys allows the researcher to gather data from a larger sample to create more in-depth insights and test the proposed propositions.

- This research was undertaken in Australia. Future research can extend this framework to other developed countries such as the UK and Canada to further explore the BDA adoption strategy and see how the supply chain processes are likely to benefit there.

- This thesis employs a single theory which is the TOE framework to investigate BDA adoption in the pharmaceutical supply chain context. Although this theory is supported by

literature in BDA adoption, complementing this theory with other theories such as resource-based view, diffusion theory, and information processing theory may further contribute to the growing body of literature in BDA adoption.

- This thesis investigates the advantages of BDA adoption in decision-making in SCOR processes. Future research can extend the current conceptual framework by investigating the influence of BDA adoption on supply chain performance and then on organisational performance.

6.6 Summary of Chapter

This study has investigated the determinants of BDA adoption and the influence of BDA adoption on SCOR processes within the context of the Australian pharmaceutical supply chain. The analysis of the qualitative data, informed by the TOE framework, delineated BDA determinants across the three contexts of technology (relative advantage, technological capability, and data quality), organisation (top management support and organisational readiness), and environment (government policies and regulations and trading partner pressure). The research also outlined the benefits of BDA adoption in improving decision-making in each SCOR process (plan, source, make, deliver, and return). This study considered the Australian pharmaceutical supply chain as a whole by investigating all the major actors (manufacturers, wholesalers/distributors, and hospital pharmacies) in order to build an in-depth picture. This chapter discussed the theoretical and practical contribution of BDA adoption in the industry and offered several recommendations to facilitate BDA adoption in the Australian pharmaceutical supply chain. Several research limitations and directions for future research were also provided.

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Appendix A: Interview Questions

General Questions

1. Please indicate what your current job is and what responsibilities you have.
2. Please explain what products or services your organisation offer.
3. Please briefly talk about your organisation's customers, trading partners, and competitors.

Current Situation

1. To what extent does your organisation have access to data quality (accessibility, completeness, timeliness, reliability, consistency, and accuracy)?
2. To what extent do the current IT infrastructure in your organisation support the transitional data collection and exchanged with other organisations in the supply chain network?
3. To what extent do the current IT infrastructure within your organisation is sufficient to integrate big data from multiple internal and external sources for analysis?
4. What technologies does your organisation deploy to capture, store, and analyse data? Do you find it appropriate?
5. How decisions are currently made in your organisation? Is it based on facts or mangers' instincts?
6. What are the key decisions that are made in your organisation by managers regarding SCOR processes (plan, source, make, deliver, and return)?
7. What kind of data is used (or required) by managers for making these decisions?

Toward the Adoption of Big Data Analytics and its Advantages

8. Has your organisation already adopted BDA? Or plan to adopt?

9. What are the determinants that lead your organisation to adopt BDA?
10. Is your organisation under pressure from trading partners, competitors, and/or government policies and regulations to adopt BDA?
11. Does the government encourage your organisation to adopt new technology information or offer financial, technical, and training support?
12. Does your organisation staff have capability and knowledge of data analytics?
13. Does your organisation provide data analytics training to its employers? Or plan to do?
14. Has your organisation already hired new employees who have data analytics skills? Or plan to do?
15. How flexible is your organisation staff to adopt new technology information such as BDA?
16. To what extent top managers and staff are familiar with benefits BDA adoption offers to your organisation operations?
17. To what extent do top managers provide necessary resources for the adoption and implementation of BDA such as financial resources? Or plan to do?
18. Do you think data-driven decisions on SCOR processes result in the improvement of supply chain processes?
19. How does the adoption of BDA improve decisions made across SCOR processes (plan, source, make, deliver, and return)?

Appendix B: Consent Form for Participants Involved in Research

INFORMATION TO PARTICIPANTS:

We would like to invite you to be a part of a study on **"**Big Data Analytics Adoption in Supply Chain Management and its Impact on SCOR Processes: A Qualitative Study of the Australian Pharmaceutical Industry**".**

The study will aim to investigate the determinants of big data analytics adoption underpinned by technology-organisation-environment framework to improve decision-making of SCOR processes (Plan, Source, Make, Deliver, and Return) in pharmaceutical supply chain. Although earlier research has dominated the literature in big data analytics in general and across various industry contexts, the use of big data analytics in pharmaceutical supply chain needs further investigation. Some interviews will be undertaken with pharmaceutical manufacturers, wholesalers/distributors, and public hospital pharmacies in Australia to drill down information to support the conceptual framework. The interviewees will be the supply chain managers and/or data analysts in these organisations. These interviews do not have any potential risks for the participants. Then, N-Vivo software will be used to analyse the data collected from these interviews. It is expected that this research has both theoretical and practical contribution.

CERTIFICATION BY PARTICIPANT

I, "[Click here & type participant's name]"

of "[Click here & type participant's suburb]"

certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study:

"Big Data Analytics Adoption in Supply Chain Management and its Impact on SCOR Processes: A Qualitative Study of the Australian Pharmaceutical Industry" being conducted at Victoria University by: Dr. Himanshu Shee

I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed here under to be carried out in the research, have been fully explained to me by:

Maryam Ziaee

and that I freely consent to participation involving the below mentioned procedures:

- Interview
- Observation

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be kept confidential.

Signed:

Date:

Any queries about your participation in this project may be directed to the researcher

Dr. Himanshu Shee

Phone Number: 0399194077

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email Researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

[*please note: Where the participant/s are aged under 18, separate parental consent is required; where the participant/s are unable to answer for themselves due to mental illness or disability, parental or guardian consent may be required. REMOVE THIS NOTE WHEN USING THIS TEMPLATE]

Appendix C: Information to Participants Involved in Research

You are invited to participate

You are invited to participate in a research project entitled "Big Data Analytics Adoption in Supply Chain Management and its Impact on SCOR Processes: A Qualitative Study of the Australian Pharmaceutical Industry".

This project is being conducted by a student researcher Ms Maryam Ziaee (ID: 4526590) as part of a PhD study at Victoria University under the supervision of Dr Himanshu Shee from Institute for Sustainable Industries & Liveable Cities.

Project explanation

The study will aim to investigate the determinants of big data analytics adoption underpinned by technology-organisation-environment framework to improve decision-making of SCOR processes (Plan, Source, Make, Deliver, and Return) in pharmaceutical supply chain. Although earlier research has dominated the literature in big data analytics in general and across various industry contexts, the use of big data analytics in pharmaceutical supply chain needs further investigation. Some interviews will be undertaken with pharmaceutical manufacturers, wholesalers/distributors, and public hospital pharmacies in Australia to drill down information to support the conceptual framework. The interviewees will be the supply chain managers and/or data analysts in these organisations. These interviews do not have any potential risks for the participants. Then, N-Vivo software will be used to analyse the data collected from these interviews. It is expected that this research has both theoretical and practical contribution.

What will I be asked to do?

The participants will be approached for their consent to providing information via participation in an interview which takes about one hour.

What will I gain from participating?

Findings from this study will benefit the practice in pharmaceutical supply chain. It will provide managers with a better understanding of their own businesses and markets where they can take informed decisions about the future logistics of pharmaceutical products (Hahn & Packowski 2015; Klatt, Schläfke, & Möller, 2011; Lee et al., 2013; Pearson, 2014; Schläfke, Silvi & Möller, 2012). These benefits include greater customer service, optimum inventory management, efficient order fulfilment, and quick responses to supply chain challenges (Pearson 2014). Planning analytics will help players predicting their aggregate demand and supply in their strategy to meet the market requirements. While most pharmaceutical manufacturers and suppliers are located outside Australia, sourcing analytics will help them to choose the right products at the right price from the right suppliers. The distributors and retailers will be able to complete the strategic procurement, storage, and delivery of pharmaceutical merchandise in cost-effective way using delivery analytics. Return analytics will help in the reverse flow of products from downstream to upstream using the data-driven decision.

How will the information I give be used?

The data gathered through interviews will be analysed by N-Vivo Software. Then, the conceptual framework and research questions proposed by this study will be assessed and modified according to the analysed data to find out a comprehensive picture of Australian pharmaceutical supply chain.

What are the potential risks of participating in this project?

There is no risk for the participants.

How will this project be conducted?

In this study, qualitative approach will be employed. For conducting the interviews, the participants will be approached for their consent to providing information via participation in an interview. Participants are chosen among pharmaceutical manufacturers, wholesalers, and public hospital pharmacies. A semi-

structured interview questions adapted from established state-of-the art literature will be designed to expand our understanding of big data analytics adoption determinants and its impact on SCOR processes. The interview questions will be structured around big data analytics adoption and SCOR processes. Approximately 20 interviews will be conducted and the interviewees should be supply chain expert or data analysts. For analysis of the data gathered through interviews, N-Vivo software will be used. This approach allows assessment of whether the conceptual framework developed from the literature is a good fit to the observed data.

Who is conducting the study?

Victoria University - Melbourne

Dr. Himanshu Shee – Email: himanshu.shee@vu.edu.au

Maryam Ziaee - Email: maryam.ziaee@live.edu.vu.au

Any queries about your participation in this project may be directed to the Chief Investigator listed above.

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

Appendix D: Ethics Approval Letter

Dear DR HIMANSHU SHEE,

Your ethics application has been formally reviewed and finalised.

» Application ID: HRE18-074

» Chief Investigator: DR HIMANSHU SHEE

» Other Investigators: MS Maryam Ziaee, PROF AMRIK SOHAL

» Application Title: The Development of Big Data Analytics Capability across SCOR Processes to Improve Supply Chain Performance: a Qualitative Study of Australian Pharmaceutical Industry

» Form Version: 13-07

The application has been accepted and deemed to meet the requirements of the National Health and Medical Research Council (NHMRC) 'National Statement on Ethical Conduct in Human Research (2007)' by the Victoria University Human Research Ethics Committee. Approval has been granted for two (2) years from the approval date; 22/08/2018.

Continued approval of this research project by the Victoria University Human Research Ethics Committee (VUHREC) is conditional upon the provision of a report within 12 months of the above approval date or upon the completion of the project (if earlier). A report proforma may be downloaded from the Office for Research website at: http://research.vu.edu.au/hrec.php.

Please note that the Human Research Ethics Committee must be informed of the following: any changes to the approved research protocol, project timelines, any serious events or adverse and/or unforeseen events that may affect continued ethical acceptability of the project. In these unlikely events, researchers must immediately cease all data collection until the Committee has approved the changes. Researchers are also reminded of the need to notify the approving HREC of changes to personnel in research projects via a request for a minor amendment. It should also be noted that it is the Chief Investigators' responsibility to ensure the research project is conducted in line with the recommendations outlined in the National Health and Medical Research Council (NHMRC) 'National Statement on Ethical Conduct in Human Research (2007).'

On behalf of the Committee, I wish you all the best for the conduct of the project.

Secretary, Human Research Ethics Committee

Phone: 9919 4781 or 9919 4461

Email: researchethics@vu.edu.au

Appendix E: Examples of Quotes for Cross-case Thematic Analysis

Theme	Sub-theme	Manufacturers	Wholesalers/Distributors	Public Hospital Pharmacies
Data Quality	Inter-organisational Data	*We've got wholesalers and they sell out to pharmacies. It would be really interesting for us to know how much stock on hand is at the pharmacies, because if they're running low ahead of projection--well the data's there, it's all held on a computer. They know how much stock they've got, but they don't share that with us.(Manufacturer M)* *In terms of the data we're accessing, so we're constantly getting feeds of IMS data to show what activity is happening within the marketplace which also gives us some insight into any molecules [components of drugs] that we are in competition with if there's any shortage of that sort of products or whether we're seeing any uplift in any of those products. (Manufacturer L)* *If Manufacturer X goes out of stock, I wouldn't know, and all of a sudden, my demand has doubled and that's why we run out of stocks. So, this is where you try to talk with wholesalers. The wholesalers won't talk to you about other manufacturers' products. It's like a professional courtesy; they*	*With some of the wholesalers, we have monthly meetings to look at any trend that they're seeing directly on their side. So, they'll be sharing a lot of data with us -- basically all of the turns of inventory that are happening within their systems, we're seeing that and that's being shared, so we're able to adapt. (Manufacturer L)* *We rely heavily on HPV for usage data, so they give us twelve-month usage data on their procurement contracts. So, any procurement contract that they manage whether it be pharmaceutical, wound care, medical consumables, they provide the manufacturer or the distributor a projected usage and we populate that into our system and then our system breaks it down onto a daily basis. (Wholesaler/ Distributor F)* *More accurate data would help significantly, there's no doubt about that, because whether it's from individual customers or*	*We don't get granular-level access of what other hospitals are doing. It'd be nice to have, but I guess everyone's probably a little bit precious about their data. … But at the same time, there's plenty of evidence out in the literature to say that collecting this data and aggregating it and putting it out in the public space actually has many economic benefits -- different companies can analyse it, the ideas and concepts can come from it rather than hiding it all. So, health suffers from the opposite to big data which is siloed data. So, there's probably big data around, but a lot of it is siloed, disconnected, not used and analysed. So, people are collecting data, very few people actually use the data for something meaningful, and even if they do run a report off it, there's probably even less data used for turning data into information and then into decision-making. (Hospital A)* *At a macro level, the silos are government resistance to*

		won't tell you what's happening, or what other manufacturers are doing. So really you only know what you know, you don't know what else is happening. It's very hard, we're not very good at finding out what's happening out in the marketplace. So, that's why I wanted to describe … our demand/supply is quite complicated; it's very IT intensive, and it works pretty well, but no matter how good that is, it's still only looking at Manufacturer M. (Manufacturer M)	*HPV the data is quite inaccurate and they could understate or overstate. … So, anything that improves the accuracy of the data would help. (Wholesaler/ Distributor H)*	*probably put out and share data. At a hospital or at an inter-hospital level, hospitals are probably a bit reserved about sharing data with other hospitals. I think because everything's performance-driven these days and so I'll only tell you what I have to tell you; but if I found out or another hospital found out that we're doing better, then they might get more funding than us. (Hospital A)* *Nostradata and IMS, they warehouse data. That will give you the data for pharmacy sales, and only for the pharmacies that sign up to their data service. The other one does how many scripts have been written by healthcare professionals. The problem with this is that data is three months old by the time we get it; we get January's data in April; we get February's data in May. It's too late. We're in the digital world; it is 2019 -- I should be able to get that today. Why does it take three months to roll it up? So, our sales guys who are doing the forecasting that's what they look at trends in pharmacy sales and doctors writing scripts, but their data's three months old. (Manufacturer M)*
Organisational Readiness	Robust IT Infrastructure	*We use a combination of the internal system. So, we use salesforce.com, so the commercial folks when they're interacting with healthcare*	*We have our own IT department that manages the maintenance of our tools and infrastructure, so we can actually access the data*	*Most of the decision-making is probably Excel. So, Microsoft Excel and Pivot tables probably is where a lot of the work is done in*

		professionals, they'll use Salesforce. There's other areas of the business that uses Veeva System. There's obviously the Systems, Applications, and Products (SAP) database and everything that sits within that. The finance team are feeding data into Tableau, so they're the internal systems that we're using to gather data. (Manufacturer L) *We've got various decision support tools which exist within the system. Our system is J.D. Edwards, where all the transaction processing happens. But then we've got IBM COGNOS BI as one of our tools for where all the data is stored. So, we've got various data warehouses anyway, but then it feeds off into various systems. (Manufacturer N)*	*on a regular basis. From within the data, we have some already prepared templates that is produced so that we can actually check the temperature of the business. So, there are certain reports that come out on a daily basis and senior execs to junior people they actually watch it to see things like our service levels, our field rates etcetera, how we are going against our procurement versus what we are selling. So, there are some tools there which have been created internally and we use them on a regular basis. (Wholesaler/ Distributor I)* *It depends on the wholesaler. So, a big part of my job is to largely deal with the four biggest wholesalers which are Symbion, Sigma, API and CH2. And they're all at different levels of maturity. So, Wholesalers X and Y have terrific IT and I can log in and I can get data from them and we collaborate quite maturely as far as data information shares. Whereas other wholesalers they can barely run their own computer systems let alone share anything. So, it's at different levels of maturity. (Manufacturer M)*	*reality. Once I've taken the data and sort of done end of month reporting and stuff -- I do tend to push it into Power BI. (Hospital A)* *The hospital pharmacies within that chain are not technologically enabled or sophisticated or funded in the public sense certainly to be able to take advantage of the data that's out there. (Manufacturer L)* *They [public hospitals] are extremely behind, some of them are using manual registers to ascertain what patient's having, what product at what time. So, they're not even using a traditional bar code or a GTIN. So that's your worst-case scenario. But then you've got others, maybe more in the private sense, … that are fully enabled, scan their patient in, everything that goes to the patient's scanned and logged and information's flying back and forth between all of the stakeholders within the chain. … We deal with huge customers in Australia that aren't even on Electronic Data Interchange (EDI) ordering with us. So, we've literally got them at one end generating a purchase order and us at the other end keying it into a system and it is 2018 and EDI's been around for*

				how long, twenty years. (Manufacturer L)
Organisational Readiness	Skilled Human Resources	*There is a specific functional area which manages the analytics and the systems in terms of data warehousing and report generation, and that team actually does the job. They constantly have sessions for training whenever they upgrade, something for all the people who have got access to write reports or even use the reports. … And they would make sure that the end users are properly trained to use such systems to get data that they're usually looking at. So, the answer to the question is definitely there is a lot of resources put aside to manage that and time as well to make sure that people are properly trained. (Manufacturer N)* *When I think back previously to Manufacturer X, within the supply chain I had an IT guy that was a supply chain IT guy specific. All of this work was his bread and butter. In Manufacturer L, I don't have a dedicated resource that looks after that type of thing, so I don't even have an expert within my own team. And I think that issue is replicated throughout many businesses whether they be hospitals, compounders, wholesalers, and manufacturers. (Manufacturer L)*	*Basically the sales department have some analysts that will do it, PI analyst, and similarly purchasing department will have it, the forecasting guys will have it, and similarly the accountants will have it. So every department will have it because everybody wants a different data set than the other person. (Wholesaler/ Distributor F)* *…we've got our business analysts that are actually embedded in the supply arm in the business units doing that. So actual analytics is … there is a sub-section of it but the majority of the reporting is actually reporting by definition. It's a subtle difference but the word does get used a lot and when you start using the word analytics then everyone starts looking at dashboards. And we don't use a lot of dashboards in our supply, we do use them but the majority of the data that we use and the decisions that are made are based on reporting. (Wholesaler/ Distributor H)*	*There's no data scientists. There's some analysts but you actually need data scientists and you actually need clinicians who actually know the clinical question and you need the people who actually have the skills for extraction. (Hospital C)* *If you go to the public section of hospitals, the biggest barrier is resource in terms of head count and money, and also dedicated people that can work on these sort of projects and the technical experts. (Manufacturer L)* *I think unfortunately, a lot of the executives-- you'd have to show them how to use a Pivot table-- (Hospital A)* *I think in ten years' time, we'll be in a better position than we are now, because big data's been talked about; Access to our data is now becoming a little bit more realistic for a whole lot of reasons, and the inter-operability and integration is becoming a bit better. For example, there's a doctor who works partly for me who is a data scientist. His original training was data science and then he went off and did medicine, which is a fantastic combination because he can deal with the clinical and the technical*

				side of things. So, he's got access to some of our data and for the first time we're starting to ask questions of our data. But that's quite unusual at this time, but that will change. (Hospital C)