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Digital Strategies to Improve the Performance of Pharmaceutical Supply Chains

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This is to certify that the doctoral study by

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has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
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Abstract

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MBA, DBIM, South Gujarat University, 2001

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Abstract

Some supply chain managers at pharmaceutical companies lack strategies to digitalize integrated supply chain systems impacting their profitability. Digitalized supply chain management in a pharmaceutical company can help reduce operation costs, improve assets, enhance shareholders' value, positively respond to customer demand, and generate profits. Guided by the theory of constraints, the purpose of this qualitative multiple case study was to explore strategies some pharmaceutical managers use to digitalize integrated supply chain systems to increase their profitability. The participants were five managers from four pharmaceutical companies in New Jersey with strategies to digitalize their integrated supply chain systems. Data collection included semistructured video conferencing interviews and publicly available company documents analysis. Data were analyzed using the six-step thematic process, and three themes emerged: (a) constraints or barriers in current supply chain system, (b) digital technology enablers, and (c) sustainable, resilient, and agile supply chain systems. The primary recommendation for pharmaceutical supply chain managers is to identify constraints and then follow a digital road map using digital enablers. Implications for positive social change include the potential to improve the delivery and quality of pharmaceutical products needed for patient care.

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Dedication

I dedicate this study to the vaccine researchers of pharmaceutical companies and front-line healthcare workers globally for their courage and faith in braving the Covid 19 pandemic. Amazing and humbling, pharmaceutical company researchers and front-line healthcare workers continue to serve humankind. Thank you.

Acknowledgments

First and foremost, I thank God for providing me resources and mental fortitude I needed to fulfill my desire of achieving a prestigious doctoral degree. My heartfelt thanks to my chair, Dr. Kenneth Gossett, for his support and guidance throughout my doctoral journey. My heartfelt gratitude to my second committee member, Dr. Robert Banasik and Dr. Judy Blando, my university research reviewer, for their invaluable insights.

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Section 1: Foundation of the Study

The digital supply chain in a pharmaceutical company is known as the strategic and operative exchange of information (product, design, research, and competition) between stakeholders, such as suppliers, manufacturers, logistics service providers, customers, and regulatory agencies (Singh et al., 2016). The digitalization in supply chain helps build a new type of sustainable, responsive, and resilient supply network because the complex pharmaceutical supply chain involves life-saving interests and requires the mandatory participation of stakeholders (Haddud et al., 2017; Korpela et al., 2017). Digitalization has fostered a new era of competitiveness using digital strategies, digital enablers, digital system integrators, and application technologies (Ehie & Ferreira, 2019). Using digitalization to reduce operational costs and make the process effective is thus a necessity for profitability in a pharmaceutical industry. Slow supply chain digitalization impedes the firm from competing against top competitors and increasing market share (Dalal & Akdere, 2018; Kane et al., 2015). The degree of digitalization in the supply chain can help determine the success of real-time inventory monitoring, collaboration, integration, customer interaction, and efficiency, which can lead to improved performance and profitability (Iddris, 2018).

Background of the Problem

The growing complexity of managing a supply chain influence the performance of an organization (Kamalahmadi & Parast, 2017). Business managers in pharmaceutical organizations face significant threat levels by not embracing digital transformation in

supply chain business processes. According to researchers, 27% of business have suffered damage to their reputations, 58% have lost productivity, and 38% have reported reduced revenue from supply chain disruptions (Paul et al., 2017). The constraints that leaders of pharmaceutical companies face include stringent regulations, stakeholder alignments, third party logistics, regulated pricing, demand sensing, and counterfeit products in addition to different nature of goods that are being delivered through pharmaceutical supply chains (Yousefi & Alibabaei, 2015). High margin gained from sales of original products has allowed pharmaceutical industries to afford high supply chain costs and pay less attention to enhance supply chain efficiency (Merkuryeva et al., 2019). The business managers in the pharmaceutical companies spend one-third of their revenue on supply chain management (SCM) activities because of flawed transportation infrastructure and misalignment between stakeholders (Tyagi & Agarwal, 2014). In a competitive global environment, supply chain agility and reliability are the most critical elements in the success of an organization, but the current situation is less assured (Jacques, 2017).

Problem Statement

Managers in an organization need to improve efficiency and visibility in the supply chain system because the growing complexity to manage a supply chain system has resulted in supply chain disruptions that negatively impact organizational performance and increase the cost (Kamalahmadi & Parast, 2017). Supply chain disruptions have cost a specific firm more than $17 billion in lost revenue (Wang et al.,

2017). The general business problem is that some pharmaceutical managers lose supply chain efficiency, visibility, profitability, and business by not digitalizing the supply chain system. The specific business problem is that some pharmaceutical managers lack strategies to digitalize the integrated supply chain system to increase profitability.

Purpose Statement

The purpose of this qualitative multiple case study was to explore the strategies used by some pharmaceutical managers to digitalize the integrated supply chain system to increase their profitability. The target population consisted of five managers from four pharmaceutical companies in New Jersey who have successfully developed strategies to digitalize the integrated supply chain system to improve their business practices and profitability. The study findings may enable pharmaceutical managers to identify and implement value-added strategies to digitalize their supply chain system, which could help reduce operating costs, improve profitability, and contribute to national, state, and local economies. Pharmaceutical managers could also facilitate increased availability and distribution of noncounterfeit medicines to patients at lower prices to effect positive social change.

Nature of the Study

There are three types of research studies that researchers may use: quantitative, qualitative, and mixed (Yin, 2018). Researchers using a quantitative research design acquire generalized knowledge and make statistical inferences to a broad population through a population sample (Saunders et al., 2019). I chose a qualitative, multiple case

study to explore the digital supply chain strategy used by some pharmaceutical managers for digitizing their supply chain system. A qualitative research design allows investigators to focus on broad context and business problem of an organization. The qualitative research method also helps researchers understand participants' views and experiences (Merriam & Tisdell, 2015). Often, a new avenue for further analysis opens if the response is unanticipated by researchers. The mixed method research design combines quantitative and qualitative research techniques to address more complicated research questions and develop a deeper theoretical understanding (Saunders et al., 2019). The mixed method approach was not appropriate for this study because I did not need the quantitative method to answer the research questions about strategies to digitalize the integrated supply chain system. Therefore, the qualitative research design was more appropriate for this study than quantitative or mixed method research designs.

Ethnographical, narrative, phenomenological, and case study designs are the four types of qualitative research designs most commonly used by researchers (Ridder, 2017). An ethnography research design is used to investigate beliefs, behaviors, and rituals of unknown cultures by living, observing, and talking to persons with these cultural differences (Saunders et al., 2019). For these reasons, ethnography was not suitable for this study. Researchers using narrative analysis explore and analyze the experiences of participants through personal stories rather than collecting data from specific interview questions (Saunders et al., 2019). In the narrative analysis, researchers focus more on human knowledge and personal experiences. For these reasons, I did not use a narrative

research design. Phenomenological research was also not appropriate for this study because I did not intend to describe and interpret the participants' meanings or lived experiences of a particular event (Marshall & Rossman, 2016). A single case study design is appropriate when exploring a specific and complex phenomenon within its real-world context (Yin, 2018). A multiple case study is an approach used by researchers to analyze the questions of *what*, *how*, and *why* of a phenomenon and obtain and compare experiences and perspectives concerning a specific situation occurring across multiple distinct cases (Yin, 2018). Using a multiple case study design, I collected, analyzed, and compared data regarding the various strategies from those who have successfully digitalized the integrated supply chain system.

Research Question

The research question for this study was "What strategies do pharmaceutical managers use to digitalize their integrated supply chain system to increase profitability?"

Interview Questions

1. What strategies did you select to digitalize your organizations' supply chain system?
2. What were the digital processes and tools that you selected to digitalize your supply chain system?
3. What were the criteria for selecting these digital tools and strategies?
4. How did you assess the effectiveness of your strategies for meeting your expectations?

5. What were the primary barriers to implementing the strategies for digitizing your organizations' supply chain?
6. How did you address the key barriers or constraints to implementing your organizations' digital strategies for mitigating disruptions in the supply chain system?
7. Based on your experience, how have these digital supply chain strategies helped you improve your organizations' performance?
8. What additional information would you like to share concerning the strategies you developed and implemented to digitalize your organizations' integrated supply chain system?

Conceptual Framework

The conceptual framework selected for this study was the theory of constraints (TOC). Eliyahu Goldratt's (1990) TOC is a system-based management philosophy to understand and identify the root causes that limit a system from achieving higher performance. With TOC, digital supply chain managers can formulate a robust design strategy in the early phase, continuously improving the digital processes by identifying and analyzing constraints and solutions for every step of the digital supply chain system. The TOC may help in providing the insights needed to determine why nondigitalized SCM fails to achieve organizational goals. A constraint is defined as elements of the factor that limits the system from doing what it was designed to accomplish (Goldratt, 1990). Constraints hamper the progress or increased throughput of an organization. Thus,

the pharmaceutical manager's failure to manage this constraint leads to declines in its productivity. The same TOC analogy can be made to the supply chain, where weak and nondigitalized supply chain links can limit the entire supply chain's effectiveness and efficiency. A digitalized supply chain system can have various constraints, such as constraints related to storage, constraints related to production, constraints related to flow, and constraints related to strategic partners' information (Okutmus et al., 2015). The TOC was used to anticipate and address the primary challenges companies face and utilize to develop their digital road map. Using the TOC, I was able to understand the strategies, processes, and tools the participating pharmaceutical managers used to digitalize their supply chains successfully.

Operational Definitions

Artificial intelligence (AI): AI is defined as the capability of different computation algorithms that allow various devices to forecast actions, processes, and trends (Segars, 2018).

Big data analytics (BDA): Big data is defined as structured and unstructured data formats continually generated from multiple sources (Grover et al., 2018).

Cloud computing: Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal effort from management or service providers (Giannakis et al., 2019).

Digitalization: Digitalization involves using digitalized data and using digital

technology, leading to change in business processes, and models to provide new revenue and value-adding opportunities (Gobble, 2018).

Digital strategy: Digital strategy is the vision and tactics of running the business differently by renovating business processes and business models enabled by digital technologies such as the Internet of Things (IoT) and AI (Westerman, 2018).

Integrated supply chain ecosystem: Integrated supply chain ecosystem is a network of interconnected supply chain firms that shares common value and depends upon each other for their survival (Liu et al., 2019).

Internet of Things (IoT): IoT is a framework based on the availability of objects, heterogeneous devices, and interconnection solutions that provides shared information based on a global scale to support the design of applications involving people and the representation of objects (Atzori et al., 2017).

Supply chain management (SCM): SCM is an integrated process for efficiently managing the supply chain operations to deliver value to the stakeholders and increasing and working toward enhancing supply chain performances (Kumar & Kushwaha, 2018).

Assumptions, Limitations, and Delimitations

The purpose of this section is to define assumptions, limitations, and delimitations. Researchers use assumptions to justify decisions they make concerning the research design and promote research synthesis (Wolgemuth et al., 2017). Limitations are weaknesses a researcher must be aware of and address that can affect the validity of the research (Cypress, 2018). Delimitations are purposeful biases formed by the researcher

during the design of the study (Price & Murnan, 2004). Limitations are biases not controlled by the researcher, and delimitations are biases the researcher does control (Price & Murnan, 2004).

Assumptions

To ensure quality, researchers must identify and mitigate risk from assumptions by explaining exclusion and inclusion decisions and their impacts on research findings (Wolgemuth et al., 2017). The assumptions that contributed significantly to the quality of this study were: (a) the participants understood and answered the interview questions honestly, truthfully, and without any bias; (b) the participants have the significant professional knowledge in the supply chain and managed digitalized supply chain in the pharmaceutical domain; (c) the participants surveyed for this study have decision-making authority or can influence decisions in their organizations; and (d) as generated from the interview session, the audio and video recordings and transcripts were accurate vocal representations of the participant's response to semistructured, open-ended questions.

Limitations

A study's limitations represent the potential weakness, restrictions, and shortcomings in the study that is out of the researcher's control in most cases (Busse et al., 2017). Limitations are also the restrictions on the interpretations and conclusion because of the chosen methodology and research topic (Greener, 2018). A potential limitation is the small size of the research population and short time limit of the case study. Another limitation may arise by restricted data from archival documentation

because of the pharmaceutical company representative's interest in protecting intellectual property rights.

Delimitations

Delimitations are boundaries or restrictions intentionally placed by researchers to limit the study's scope (Andrade, 2019). Delimitations are boundaries established by researchers to narrow the scope of the study (Holloway & Galvin, 2017). The study was limited to the pharmaceutical managers located in the United States, representing the study's validity. Thus, the delimitations of the study are the geographical limitation of scope to the United States.

Significance of the Study

The study's findings are significant to enhance organizations' supply chains' efficiency and effectiveness. Some pharmaceutical companies' managers are traditionally resistant to technology change when digital transformation is becoming a prerequisite for ensuring supply chain efficiency, visibility, speed, and quality (Jacques, 2017). But using digitalization, managers can add value by increasing reliability, robustness, and flexibility of supply chain planning, implementation, and improvement (James, 2017). The strategies could also contribute to positive social change by reducing the adverse events caused by counterfeit and compromised drugs. The following subsections include the potential specific contributions to the specific business practices and social change implications.

Contribution to Business Practice

The pharmaceutical industry's supply chain complexity is well known as a product needs to pass through the various complex product life cycle phases (Asl-Najafi & Yaghoubi, 2021). The life cycle phases can be defined as a research or discovery phase, testing for safety and efficiency, registration with regulators such as Food and Drug Administration, meeting medical control council standards, and commercial manufacturing (Asl-Najafi & Yaghoubi, 2021). Research findings about digital supply chain strategies provide chain managers strategies for improving business practice by enhancing digitizing pharmaceutical supply chains' efficiency and effectiveness.

Implications for Social Change

This study's findings contribute to positive social change in organizations that use or plan to digitalize their supply chain processes. An effective digital supply chain strategy is critical to ensure that the managers in the pharmaceutical supply chain: (a) monitor counterfeit products and protect consumers from adverse effects, (b) implement a sustainable green supply chain to protect the environment, and (c) reduce the turnaround time and availability of counterfeit drugs (Saxena et al., 2020). The results contribute to positive social change by leading to lower prices for end consumers and improving the experience of patients who receive their medication supplies from pharmaceutical supply companies.

A Review of the Professional and Academic Literature

The objective of this qualitative multiple case study was to explore the strategies

used by some pharmaceutical managers to digitalize the integrated supply chain system to increase their profitability. This literature review is organized as follows: the conceptual framework of TOC, overview of digitalization, pharmaceutical industry, digital supply chain in general, pharmaceutical supply chain and its challenges, road map in the pharmaceutical supply chain, digital enablers, disruptions, and agility in the supply chain, and finally sustainability in the digitalized integrated supply chain system.

Search Strategy

The literature review included an integrated review of articles from the databases of Walden University Library, EBSCOhost, Google Scholar, numerous business journals, ProQuest, and SAGE Publications. Search terms for conducting research for the literature review included *digitization, digitalization, digital supply chain, pharmaceutical supply chain, IoT, Big Data, AI, Cloud, disruptions, agility, sustainability, conceptual framework, the theory of constraints,* and *qualitative research* or a combination of keywords.

The review of the literature included 124 peer-reviewed references, out of which 15 references accounted for 12% and were published prior to 2017 (see Table 1). The remaining 109 were published between 2017 through 2021, which accounted for 88% that were published within 2017–2021. The doctoral study included 162 peer-reviewed references, out of which 16 references accounted for 10% that were published prior to 2017. Between 2017 through 2021, 146 references were published, which accounted for 90%.

Table 1

Sources of Data for Literature Review and Doctoral Study

	Lit. review sources published prior 2017	Lit. review sources published on or after 2017	Total	Total references prior to 2017	Total references on or after 2017	Total	Total references
Books	2	0	2	1	2	3	5
Peer-reviewed	15	109	124	16	22	38	162
Non-peer-reviewed	7	4	11	0	0	0	11
Total % of peer-reviewed resources after 2017	12	88	**75**	42	58	79	**90**

Note. Number and percent of references published before and after 2017. Ulrich's periodicals directory is used to verify peer-review status. References were from peer-reviewed journals and books of which the literature review accounted for **75%** and the doctoral study accounted for **90%** of peer-reviewed journals published within the last 5 years.

Conceptual Framework: Theory of Constraint

The conceptual framework selected for my doctoral study was the TOC. Goldratt's (1990) TOC is used for reviewing organizational performances regarding efficiency, visibility, and profitability by digitalizing the integrated supply chain eco system. I selected the TOC as the conceptual framework mainly because business managers have found the TOC effective in achieving their goals. The objective of every

organization is to make a profit, and the constraints are the major obstacles for not achieving the goals. The inadequacy of traditional management and global competitiveness is the primary reason organizational managers adopt TOC as a continuous process framework to achieve the goals (Okutmus et al., 2015). Researchers use the TOC to help identify, leverage, and remove constraints in its operations (Kuruvilla, 2017; Trojanowska & Dostatni, 2017).

The pharmaceutical industry's business managers may use TOC to identify constraints and challenges associated with supply chain strategies and find a solution to overcome those challenges. Business managers of most organizations implement TOC as a broad-based operation management strategy for improving profitability, effectiveness, and efficiency throughout the manufacturing process (Modi et al., 2019). The TOC suggests that most real-life systems are inherently simple and not complex because of few root causes or constraints. Treating those symptoms may not yield substantial improvement in the process, and the only way to eliminate it is by addressing the system's proper constraints (Modi et al., 2019).

There are five cyclical steps during business improvement processes while using TOC (Goldratt, 1990; Okutmus et al., 2015). The steps can be described as (a) identify the constraints that are currently preventing the firm from achieving the goals; (b) exploit the constraints by determining the necessary actions to bring about desirable change or effects; (c) subordinating every related decision to the constraints by focusing only on constraints as other functional department is linked with the department, that is affected;

(d) elevating the constraints by expanding the capacity of the department to eliminate the constraints; and (e) discovering, evaluating, and eliminating the new constraints in an endless cycle that leads to continuous improvement process inside the organization. TOC's cyclical structure indicates how business leaders identify, exploit, subordinate, elevate, and repeat to eliminate the constraints.

A constraint can occur anywhere within manufacturing, including supply chain, logistics, or internal processes. Five different types of constraints include (a) market constraints, (b) capacity constraints, (c) logistics constraints, (d) behavioral constraints, and (e) administrative constraints (Okutmus et al., 2015). The market constraint is prominent in the pharmaceutical supply chain because customer demand and manufacturing mismatch are frequent. Capacity constraints relate to poor supply chain planning as an existing resource is insufficient to meet the market demand. Logistics is an integral function of the supply chain as it plans, implements, and controls the flow of raw materials, semi, and finished material for meeting customer's requirements (Kudláč et al., 2017; Okutmus et al., 2015). Any constraint that pertains to logistics will adversely impact the supply chain efficiency. The administrative constraint is mostly related to organizational policies and the limiting factor toward hindering workflow (Okutmus et al., 2015).

The pharmaceutical supply chains are traditionally complex, and using TOC is valid for such industrial segments. What makes the task of managing a typical supply chain so complicated is that many suppliers supply a large variety of raw materials,

including active pharmaceutical ingredients and active biological ingredients, to large manufacturing sites that produce a large variety of products. The products are then shipped using several transportation methods to a vast number of customers and logistic service providers located around worldwide (Modi et al., 2019).

Complementary Theory

Competitive Advantage Theory

Managers in pharmaceutical industries may use the theory of competitive advantage to complement the TOC for gaining a competitive edge. Competitive advantage theory is a widely tested framework for planning and innovation that works through a value chain, and each link encompasses activities to add value to the entire value chain (Pontinha et al., 2020). Porter's (1980) competitive advantage theory suggests optimal utilization of resources and decisions made based on all levels, such as national, corporate, local, and individual. Manufacturing business leaders may use competitive advantage theory to differentiate products and services from competitors by offering customers unique products and services at a lower cost (Bel, 2018).

Porter (1980) discussed three approaches toward developing a successful competitive strategy known as generic strategies: focus, differentiation, and the cost of leadership. Business leaders can serve a targeted segment and specific market by focusing on unique products and services teller made for that market. Focusing on specific target helps business leaders to limit vulnerability from competitors. Differentiation helps business leader's ability to produce unique products of services for

gaining an advantage over competitors. The cost of leadership refers to the business leaders' ability to maintain cost to achieve a larger return on investment.

Digitalization may not directly affect competitive advantages but has strong indirect effects on products and service advantages (Lee & Falahat, 2019). Competitive advantage is the extent to which an organization can create a defensible position over its competitors (Porter, 1980). Competitive advantage is expressed regarding reducing product development cycle, cost, flexibility, quality, delivery, and sustainability (Liao et al., 2017). Business managers must adopt digitalization and be ready for suitable digital tools to accelerate the competitive advantage process over their competitors. (Lee & Falahat, 2019)

Contingency Theory

Contingency theory is also considered as a complementary theory to the TOC. Contingency theory emphasizes the importance of the situational context in which managers operate. Business managers use contingency theory in decision making and best practices and unique tools to address the current situation, and not as a generic selection of tools (McAdam et al., 2019; Prester et al., 2018). There is no single best way to manage leadership processes, decision-making, and process of organizing as different environments offer different antecedents in contingency theory (Romero-Silva et al., 2018). Leadership in organizations may adopt contingency theory to support leadership decision-making and achievement of competitive advantages using various diverse strategies that fit and applicable to a particular situation (Williams et al., 2017).

Organizations must take a contingency approach of entrepreneurial orientations and strategic vision on digitalization (Niemand et al., 2020). Contingency theory helps managers to view firms as an open system where information is exchanged through the input-process-output procedure (Romero-Silva et al., 2018). Input consists of contextual internal and external issues, processes indicating organizational responses to these inputs, such as strategies, and output refers to these processes' results. Business managers must develop a clear vision regarding digitalization characterized by innovation, being ahead in competitive advantages, and a willingness to take risks (Niemand et al., 2020).

Competing Theory: Theory of Swift and Even Flow

Business managers may use the theory of swift and even flow (TSEF) instead of the TOC to focus on speed and processes to achieve better productivity. The model of productivity, also known as the TSEF, refers to flow for achieving variation reduction and the throughput time frame to drive efficiency and eliminating nonvalue-added activities from the value chain for cost reduction and efficiency enhancement (Schmenner, 2015). Supply chain managers in pharmaceutical industry often use TSEF to drive productivity and reduce cost by eliminating nonefficient activities and reducing cost. Business manager may use TSEF for making the process become more productive as its material and information flow increase speed and evenness (Yin et al., 2017). Business managers use the TSEF for a more holistic view of the operational capability of an organization (Nguyen et al., 2020).

Managers who use TSEF state that there are two factors with this theory to

productivity gains (Schmenner, 2015). The first critical factor is reducing variation, that can be of different types, such as quality, quantity, and timing. The variability can also occur as a decrease in uniformity by consequence of unpredictable demand for products or planned variation, such as breakdown and the number of products online (Nguyen et al., 2020). The second important factor is the reduction of throughput time as much as possible. Quality refers to reducing defects, quantity refers to producing the same amount each day, timing refers to producing at the exact regular timing with the same manufacturing sequence, and throughput reduction refers to the time it takes to produce from start to end (Schmenner, 2015). The productivity of any supply chain manufacturing processes, such as total factor productivity, machine and material productivity, and labor productivity, rises with speed the material move flow the processes and falls with an increase in variability associated with the flow (Schmenner & Swink, 1998). In any supply chain manufacturing system, capacity use, work in process, and variability should always balance to enhance the agility of the supply chain system (Yin et al., 2017). Business managers make better decision by developing adequate resources regarding money, time, and people to enhance supply chain fitness by taking help from theory of TSEF (Nguyen et al., 2020). However, the TSEF does not help business managers manage constraints within the processes and focus majorly on removing variations and reducing throughput.

Digitalization

Digitalization can be understood as a process of using digital technology, leading

to change in value creation, business processes, and business model to provide new revenue and value-adding opportunities (Gobble, 2018; Gong & Ribiere, 2020). Digitalization facilitates the organization toward digital transformation by automating the processes for better outcomes. Digital transformation is a fundamental change process enabled by digital technology that aims to bring radical improvement and innovation in an organization to create value for its stakeholders by strategically leveraging its resources and capabilities (Gong & Ribiere, 2020). Digitalization of business processes enables organizations in various innovations, including improved design and new process models, and shapes how organizations created enhanced values for their business partners, such as customers, vendors (Nadeem et al., 2018). The new digital technologies present essential threats to any organization and, at the same time, provide game-changing opportunities also (Sebastian et al., 2020).

Business managers need to understand the concept and difference between digitization and digitalization. Digitization is the straightforward process of converting analog information to digital (Ritter & Pedersen, 2020). For instance, turning pages into bytes by scanning a document or recording a sound is considered a digitization process. Digitalization of business process means developing digital strategies to react and apply emerging digital solutions such as the IoT, AI, cloud computing, blockchain to introduce innovation, improve, enhance, and create new business processes. Digitalization is about implementing cutting-edge technologies and not just change in the business processes. Digitalization refers to the use of digital technology and digitalized information to create

and harvest value in new ways (Gobble, 2018; Ritter & Pedersen, 2020).

The goals of organizations that plan to invest in digitalization fall into two major categories: to mitigate the risk of market uncertainties and to win competitive advantages (Gong & Ribiere, 2020). Business managers may formulate the strategy around three prominent elements to implement digital strategies to digitalize existing business strategies for their pharmaceutical organizations. These elements include (a) defining emerging digital technologies and digital solutions, (b) preparing a framework and building operational backbone for facilitating operational excellence, and (c) quickly adopting a digital service platform that enables rapid innovation and responsiveness to customer and new market opportunities (Sebastian et al., 2020). Digital transformation is a set of strategic renewal, transformation at a different level in an organization, and leadership aspects of optimizing resources and capabilities attributes, which is far beyond the use of technology alone (Gong & Ribiere, 2020).

Pharmaceutical Industry

The pharmaceutical industry is defined as a system of procedures, operational life cycles, such as drug discovery, development including testing, review and approval, oligopolistic competition, and generic competition (Lakdawalla, 2018). The companies belonging to the pharmaceutical industry segments discover, develop, manufacture, market, and distribute medicines. Classes of medicines include over the counter, Active pharmaceutical ingredients, active biological ingredients, biologics (vaccines, proteins), biosimilars, and any substances used in diagnosis, cure, mitigation, and treatment to

prevent disease (U.S. Department of Commerce- International Trade Administration, 2017). The global pharmaceutical market reached 1.3 trillion in 2020, up to $100 billion from 2017, and for the U.S. market, its 2023 spending is projected to be $625-655 billion (Vincent, 2020).

Pharmaceutical drug manufacturing is performed in batches, and equipment is mostly self-contained. Though control technologies and industrial automation are well established in pharmaceutical industries, integrated information on the equipment's real-time status or condition is still not accessible to help managers make informed decisions and improve effectiveness in scheduling batches, cleaning, maintenance (Sharma et al., 2020b). Pharmaceutical industries are also subjected to the Bullwhip effect or the phenomena in which order placed by downstream nodes to upstream nodes are variable over time and amplified further upstream from the customer (Azghandi et al., 2018). Bullwhip illusive stock effect leads to high stock in warehouses, high rate of returned products, high transportation costs, and customer dissatisfaction (Yousefi & Alibabaei, 2015). The four elements that contribute to a Bullwhip effect are (a) demand signal processing, (b) order batching, (c) rationing game, and (d) price variations (Azghandi et al., 2018). The Bullwhip effect may happen because of the lack of the right information at the right time for the right decision-maker (Yousefi & Alibabaei, 2015).

Drug development is a long and expensive process and takes about 12 years and approximately $3 billion costs to develop a new drug and to move from preclinical testing to final approval with a success rate of 10–20% only (Vincent, 2020). Business

managers from pharmaceutical companies are showing interest in niche markets, away from the saturated market or blockbuster drug market. These markets can help them grow faster even though they are low volume. Business managers are also implementing an agile supply chain by integrating information systems to increase the supply chain's speed and flexibility maker (Yousefi & Alibabaei, 2015).

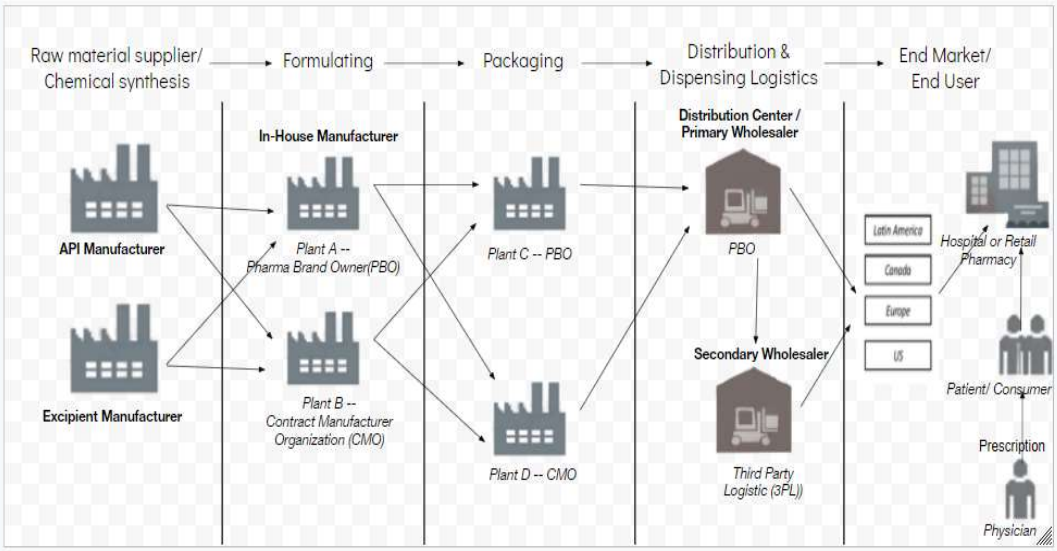
Pharmaceutical Supply Chain and Challenges

The pharmaceutical supply chain includes a network of internal and external stakeholders and their connection through which the production, supply, delivery, and sales of essential pharmaceutical products are distributed to the end users at the right place and at the right time (Sabouhi et al., 2018). The primary stakeholders in a pharmaceutical supply chain include multiple government agencies, clinics, hospitals, drug manufacturers, drug distributors, pharmacy chains, retailers, research organizations, and retailers (Kapoor, 2018). The pharmaceutical supply chain encompasses effective management of financial, information, and material flow among network components to maximize profit and customer satisfaction (Alzaman et al., 2018). After drug launching, a completely different set of objectives, drivers, and constraints become dominant (Kapoor, 2018). The same supply chain is responsible for distributing prescription drugs, over-the-counter medicines, generics, and biologics. Different handling needs and operational objectives make the matter more complicated to manage the supply chain (Kapoor, 2018). The material and money flow are different in different in pharmaceutical industries as it involves more stakeholders in each phases of supply chain. The materials

and money flow are demonstrated in Figure 1.

Figure 1

Pharmaceutical Supply Chain Product and Money Flow



Note. In this figure, I show each stakeholder in detail before the final product reaches the end user. The pharmaceutical supply chain products and money flows from various cycles, such as synthesis, formulating, packaging, distribution, and end market.

Contract manufacturing organization (CMO) serves the pharmaceutical industry with comprehensive services from drug development through manufacturing (Pandya & Shah, 2013). Deciding about owning a brand or manufacturing through contract is a strategic decision for business managers in a pharmaceutical organization. CMO refers to a strategy that firms gets the manufacturing contracts to manufacture the products for the outsourcing firm, while branding refers to a strategy that firm focus on establishing their brands through leveraging the production competence of CMO (Hsiao & Chen, 2013).

Branding strategy is adapted when firms have better R&D and marketing capabilities, and contract manufacturing strategy is adapted when firms have superior process and manufacturing capabilities (Hsiao & Chen, 2013). Supplier qualification of CMO is necessary for direct products, equipment, and even software and hardware as these impact qualities of the final pharmaceutical product. Services offered by CMO can be either primary manufacturing, which is the synthesis of bulk active pharmaceutical ingredients, or secondary manufacturing, which is a formulation of bulk drug substances into the final drug products (Pandya & Shah, 2013). Compatibility of excipient and active pharmaceutical ingredients is required for drug formulations and enhancement of active ingredients in the final dosage form, such as improving solubility and enabling drug absorption. CMO contribute an important role in pharmaceutical, and many brand owners outsource their entire operation or part of their process to CMOs. Goods are distributed either through wholesale or distribution centers managed by the brand owner or third-party logistics providers. Third-party logistics are more critical in a smaller region or when special requirements of the drug, such as cold chain, come into play. Many contract manufacturers are changing the trend by using various digitalization strategies such as (a) real-time remote tracking of production and delivery processes, (b) protecting blueprinting of production and using a secured channel for supply chains, (c) late-stage customization to reduce turnaround time depending upon market demand, and (d) use of AI for cost-effective and more productive manufacturing and use of blockchain for making technology more secured (Clifton, 2021).

For any organization, including pharmaceuticals, supply chain design includes two significant threatening risks: operational risks and disruption risks. The pharmaceutical supply chain risk management includes four stages: risk identification, risk prioritization, risk management, and risk monitoring (Osorio & España, 2020). Operational risks frequently occur and are caused by medium to high likelihood and low and short-term adverse effects (Sabouhi et al., 2018). Operational risks need to be considered as they can significantly affect the company's performance through their severity, and the impact can be lesser than disruptive (Osorio & España, 2020). Inherent uncertainties, such as customer demand, supply, and cost uncertainties, can qualify for operational risks (Sabouhi et al., 2018). Osorio and España (2020) noted that operational risks include risk associated with peoples, processes, machine, external events, and pharmaceutical companies take action to mitigate those instead of eliminating. Disruption risks have a low likelihood and can cause drastic social and economic changes. Natural disasters, human-made threats, and technological threats can qualify for driving disruption risks (Sabouhi et al., 2018). The supply chain risk management strategies include agility, flexibility, and leanness to reduce the possibility of disruptions (Eltawy & Gallear, 2017; Mohammaddust et al., 2017).

Industry 4.0 was initially established in Germany and paved the way for industrial digital revolutions (Ding, 2018). Digitalization and automation are prerequisites for Industry 4.0. Narayanan et al. (2020) noted that despite extensive growth, reaching $188 billion in sales in 2017, the biopharmaceutical sector distinctly lags in transitioning to this

aspect. The vision for industry 4.0 is to connect resources – human, data, and physical machines, and combine diverse technologies, including BDA and cloud computing (Narayanan et al., 2020). Industry 4.0 and its enabling technologies have the potential to affect every function of an organization by bringing significant improvement in supply chain and logistics management (Fatorachian & Kazemi, 2021). The ability to analyze enormous data volumes and share insights across the virtual value chain is critical to deliver innovation and respond to changing marketing dynamics. Contents and data can be stored in a regulated cloud repository so that information can be accessed anywhere in real-time. The concept of industry 4.0 by the name of pharma 4.0 is applied to the pharmaceutical industry. The realization of pharma 4.0 requires a shift in how regulatory contents and data are managed, and transformation needs to start with changes in mindset and perception of the data content (Narayanan et al., 2020). Good practice, quality guidelines, and regulations record keeping needs to be documented in electronic format as it cannot be properly managed in paper-based formatting.

Most of the pharmaceutical organizations are still under batch production rather than continuous production, which requires lower material consumption, decrease hazardous solvents, and less influence on the ecosystem regarding air emissions, chemical pollution, wastewater, and residual waste (Ding, 2018). Lack of robust online quality control and flexible production is the bottleneck of reliable drug supplies, resulting in drug shortages even in emergencies (Ding, 2018). U.S. Federal Drug Administration (2018) reported 39 new drug shortages in 2017 and 41 ongoing shortages

from previous years. Drug shortages can delay or deny needed care for patients, creating a potential lapse in related medical care (U.S. Federal Drug Administration, 2018). The factors, such as quality issues, attributed thirty-seven % to drug shortages (U.S. Federal Drug Administration, 2018). Raw material and lack of capacity attributed fifty-four % to drug shortages (U.S. Federal Drug Administration, 2018). Demand uncertainty attributed 5%, and loss of manufacturing site and discontinuation attributed 2% each in primary reason for drug shortages (U.S. Federal Drug Administration, 2018). The significant factors for drug shortages, such as manufacturing issues, raw materials shortage, lack of capacity, and uncertainty in demand, are considered supply chain events. The supply chain performances can contribute to reducing potential drug shortages. The pharmaceutical managers may take the help of various digital enablers to enhance visibility and take proactive action to mitigate these adverse events.

Pharmaceutical organizations continue to lose millions because of spoilage from temperature fluctuations and potential hazards for patients and subsequent regulatory actions (Sharma et al., 2020b). Pharmaceutical manufacturers produce the majority of biologics products, which are highly sensitive to storage conditions. Temperature monitoring of some pharmaceutical drugs must be done by following cold chain processes, whether they are in storage or in transit (Singh et al., 2020). Biological products have a large proportion of high-value active ingredients with shorter shelf lives and carry strict temperature requirements. Cold chain processes consist of (a) cold storage, (b) cold storage, and (c) cold transport (Singh et al., 2020). Biological products

have a large proportion of high-value active ingredients with shorter shelf lives and carry strict temperature requirements. These drugs must be kept in temperature-controlled containers during transport, like reefers, to avoid the spikes in ambient containers.

Digital Supply Chain

The digital supply chain has been referred to as an intelligent, customer-centric, system integrated, globally connected, and data-driven mechanism that leverages new technologies to deliver valuable products and more accessible and affordable services (Seyedghorban et al., 2020). The digital supply chain is also part of the fourth industrial revolution, also known as Industry 4.0, that helps organizations connect ecosystems within the functional area of an organization. The digital supply chain is also referred to as the smart supply chain, which is new interconnected business systems extending from isolated, local, and single company applications to supply chain-wide systematic smart implementations (Wu et al., 2016). The supply chain network includes stakeholders and the ecosystem, such as suppliers, manufacturers, warehouses, and distribution centers. The supply chain ecosystem's connections participate in the supply of raw materials, production, delivery, and sale of a product to the customers (Sabouhi et al., 2018). A SCM must encompass effective management of information, financial, and material flow among the network components to maximize the total profit and customers' satisfaction (Sabouhi et al., 2018). As per the council of SCM professionals, SCM is defined as planning and managing activities involved in sourcing, procurement, conversion, and logistics (Kapoor, 2018). A manager implementing a digital supply chain aims to

preserve the supply chain's effectiveness to satisfy customer demand and survive in competitive market.

Road Map for Digital Supply Chain Strategy in Pharmaceutical Industries

The digital strategy refers to the company's strategy applied to its strategic initiatives that include the end-to-end processes, such as requirement gathering, planning, recognizing risks and opportunities, and maintaining the digital strategy (Schallmo et al., 2019). In a survey, 73% of respondents acknowledged that digitalization helped them reach operational excellence (Lehmann, 2018). A digital strategy is the strategic form of companies' digitalization intentions when digital technology and methods are applied to products, services, processes, and business models (Schallmo et al., 2019). The growth of the business has created tighter global competition, and to survive and maintain a sustainable competitive advantage, organizations must identify emerging digital technologies for developing a new business model (Agrawal & Narain, 2018). The managers may use digital strategy to contribute a critical enabling role in encouraging business model innovations (Li, 2020). Digitalization forces organizations to reinvent their business processes and encourage them to find a new way of doing business (Bouwman et al., 2018). The digital strategy by supply chain managers may reshape the existing non-digital supply chain model to digitalized supply chain 4.0 in which automation will boost supply chain efficiencies by automating the operational tasks (Alice et al., 2020).

The digital strategy outlines the direction and provides a road map for a

pharmaceutical business to follow digitally. Digital strategy should be either wholly aligned or part of a corporate strategy rather than wholly detached from corporate strategy. An ideal situation is a scenario when the digital strategy is a corporate strategy. The digital strategy may be derived from the goals and objectives of an organization. The digital strategy consists of a vision, mission, strategic objectives, success factors, values, and measures (Schallmo et al., 2019). The digital strategy establishes the technologies, tools, platforms, and infrastructure required to accomplish the objectives outlined by digital strategy regarding delivering the results. Digitalization forces organizations to reinvent their business processes and encourage them to find a new way of doing business (Bouwman et al., 2018). The digital strategy by supply chain managers may reshape the existing non-digital supply chain model to digitalized supply chain 4.0 in which automation will boost supply chain efficiencies by automating the operational tasks (Alice et al., 2020).

Business managers from pharmaceutical industries should have a deep understanding of and possibilities of digital supply chain integrated eco system compared to traditional supply chain system. Traditional supply chains are increasingly becoming intelligent by turning into digitals using sensors for better communication, automation capabilities, and intelligent decision making and presents vast opportunities for cost reduction and efficiency improvement (Wu et al., 2016). A digitalized supply chain compared to a traditional supply chain provides opportunities that include increased information availability, optimized inter-company logistics, visibility, transparency,

efficient inventory management, integration, and collaboration (Seyedghorban et al., 2020).

The three different supply chain digitalization models are explained in detail: The first model describes the difference between traditional non-digitalized linear supply chain and digitally enabled supply chain ecosystems. The traditional non-digitalized supply chain is a series of largely discrete, siloed steps taken toward marketing, product development, manufacturing, distribution, and finally, into the customers (Schrauf, & Berttram, 2016). An integrated supply chain ecosystem helps bring transparency, communication, collaboration, flexibility, and responsiveness to non-digitalized traditional linear supply chain systems. The digitally enabled supply chain ecosystem helps in transparency and collaboration compared to traditional linear supply chain system. The model was applicable for the business managers from my target populations, who successfully moved from a traditional linear supply chain system to a digitally enabled supply chain ecosystem.

The second model applied to my target population's business managers, who implemented various integrated layers between their supply chain eco system. Integrated digitally enabled supply chain ecosystem was introduced by Behner and Ehrhardt (2016) talked about three layers in the model: (a) virtual supply chain control tools, (b) cloud-based information architecture, and (c) digitally enabled physical supply chain. Many digital tools and technologies, such as sensors, barcode, IoT, radio frequency identification, revolutionized SCM by integrating and coordinating every link of the

chain (Nguyen et al., 2020). The cloud-based architectural structure is prevalent for the inbound and outbound flow of information and decision. Cloud and virtualization are often adapted in the business process layer and are the main driver to speed up the supply chain (Borangiu et al., 2019).

The element set from the first layers of the model involving virtual supply chain control tools provides dynamic decision-making interfaces, collaborative tools, mobile analytics that helps supply chain managers to manage and oversee supply chain information from nodes, such as raw materials vendors, contract manufacturers, factories, logistics providers, distributors, customers (Behner & Ehrhardt, 2016). These analytics also helps supply chain managers to make an informed decision based upon information received in real-time. The supply chain managers use advanced analytics techniques to extract valuable knowledge from the vast amount of data, facilitating data-driven decision making (Nguyen et al., 2020). The second layer is a cloud-based information architecture that enables fast computing for the different types of data and systems to form a physical network across components of the supply chain system (Behner & Ehrhardt, 2016). Cloud is an integral part of the supply chain business processes layer, but high-performance computing, system design, and information integration can be a challenge to implement cloud (Borangiu et al., 2019). The third layer include the physical supply chain elements, such as devices, storage, manufacturing units, and logistics (Behner & Ehrhardt, 2016). These elements are digital-enabled and consistently exchange information using technologies, such as the IoT.

The third model applied to the business managers who implemented the innovative self-thinking supply chain regarding collaboration and self-learning perspective. The third self-thinking digital supply chain model was introduced by Calatayud et al. (2019). The concept of the self-thinking supply chain is very innovative regarding collaboration and self-learning perspective. Betcheva et al. (2021) found that pharmaceutical companies could decrease costs and improve efficiencies by using a thinking supply chain. The collaborative self-thinking model helps in collaboration and through self-learning. Regulating the flow of materials is often used in the pharmaceutical supply chain by switching to air transport mode instead of the sea container route in case of congestion in the sea. In practice, supply chain managers can plan accurately by optimizing the air-sea distribution system using control towers enabled through digital technologies.

Developing a business case may help the managers conduct a feasibility assessment of the various initiatives that may undergo digitalization before implementing on a larger scale. The managers fail to deliver projects because of scope, schedule, and budget creep. Effective supply chain digital strategies may provide a mechanism to give the project deliverable as required to meet the stakeholder's expectations.

Digital Enablers

Digital enablers as prominently used in pharmaceutical organizations include tool, such as the IoT, AI, cloud computing, and BDA. Digital technologies help integrate data and information from disparate sources and locations to streamlining the supply chain

operation by driving goods and services (Ehie & Ferreira, 2019). The digital technology enablers provide the backbone allowing digital transformations of industrial manufacturing (Ehie & Ferreira, 2019).

IoT

The IoT signifies smart devices connected through sensors and the Internet that performs tasks and exchange real-time data (Radoglou et al., 2019). The IoT application, such as cold chain monitoring, resources (man and machine) tracking, packaging, and warehouse management, is very much suited to pharmaceutical SCM. The IoT can help manage supply chains, improve services, and manufacture products, so pharmaceutical industries have a compelling opportunity to adopt and profit from the IoT, the game-changing technology (Sharma et al., 2020a). The rapid expansion of IoT devices provides enough potentials to the organizations by harnessing and use data collected through smart devices in the supply chain lifecycle (Akhtar et al., 2018; Attaran, 2017). Pundir et al. (2019) explained IoT as a network of uniquely identifiable endpoints or things that communicate without human interaction using I.P. connectivity, whether locally or globally. The IoT is also defined as the extended development of Internet services to consider smart objects that exist (Pundir et al., 2019). Supply chain integration is critical for improving business performances and can be achieved through cost reduction, improving responsiveness, increasing service level, and streamlining organizations' decision-making process (Pundir et al., 2019). The IoT deals with integrating and enabling information using technologies, such as radio frequency identification, wired or

wireless sensors, mobile apps, and machine to machine system and may allow device enabled decision making in supply chain system with no or minimum human intervention (Haddud et al., 2017).

The IoT has a significant role in the manufacturing, warehousing, and distribution cycle of the supply chain. Smart objects are connected to the Internet using their communication protocol and are continuously collecting and processing the data (Pundir et al., 2019). Role of IoT mostly starts from manufacturing for shop floor visibility and then to move in warehousing for real time inventory visibility, and then finally during distribution toward higher fleet management for real time cold chain processes. Temperature sensing tag is placed on container which continuously records temperatures and other environmental conditions. Data can be extracted from the cloud either in real time or later.

Drugs and vaccines are susceptible to temperature variations and may lose full potency if the temperature is not maintained even for a shorter duration during transportation (Hasanat et al., 2020). Chang et al. (2019) found that pharmaceutical manufacturing companies outsource their logistics business to a third party having optimal cold chain solutions to improve core competitiveness. IoT solutions can help pharma manufacturers remotely monitor cold chain environments in real-time by embedding sensors on tracking equipment with auto-start and shutdown mechanisms in warehouses, vehicles, or shipment using smartphones and tablets. Hasanat et al. (2020) suggested an IoT model that can provide information, such as (a) vaccine carrier

information, (b) continuous monitoring using sensors, (c) location tracking using GPS, and (d) regular and urgent notifications containing carrier temperatures, humidity and location information with a timestamp.

Smart manufacturing factory's communication system comprises a wireless sensor network for connecting sensor module and gateway, and then sensor and sensor module is distributed to necessary position in the factory (Kim & Jeong, 2019). Smart equipment using IoT solutions collects operational data and status, allows visibility across equipment, and real-time dynamic scheduling of shop floor activities (Sharma et al., 2020a). The solution helps in reducing equipment downtime, and the utilization rate improves. Sensors can also help collect metadata to identify and reduce process variability and improve production yield to enhance productivity, efficiencies, and cycle time (Kim & Jeong, 2019).

IoT also helps visibility into human and material movement across the shop floor through tracking and monitoring technologies, increasing production yield, and reducing variability (Sharma et al., 2020a). Hasanat et al. (2020) suggested the business managers build an optimal automated warehouse using IoT. The warehouse is an important area for the pharmaceutical industry. The business managers manage many storage facilities globally to ensure a continuous and timely supply of essential medicines in a cost-efficient manner. Real-time visibility and three-dimensional view of warehouse operations allow warehouse managers (a) monitor and track the storage of sensitive drugs in controlled zones, (b) optimize warehouse floor space, (c) track inventory of finished

goods, and (d) identify problem areas and assign resources to deal with issues requiring human interventions (Sharma et al., 2020a). The business managers of automated warehouses using IoT may help organizations save nineteen % of the initial cost (Hasanat et al., 2020).

IoT is an enabler to spur growth within pharmaceutical organizations. Pharmaceutical organizations were slow to adopt IoT because of a lack of understanding of IoT adaption factors despite a positive influence on the supply chain system. The major compatibility issue that hampers IoT adaption is a failure to communicate between IoT devices mapped in the supply chain system. Constraints such as privacy, reliability, authentication, access control, and security issues need to be addressed before unleashing IoT applications' unlimited potential and utility in pharmaceutical industries.

AI

Improved computational technologies and growing data of supply chain processes turning AI into one of the most critical technologies in supply chain areas (Calatayud et al., 2019). Demand forecasting, end-to-end visibility, predictive maintenance, smart factory, and integrity are some of the critical metrics in the pharmaceutical supply chain that AI technologies can help with. AI is defined as the computer's ability to independently solve problems that have not been explicitly programmed to answer (Dash et al., 2019). AI technology includes machine learning, computer vision, deep learning, cognitive computing, natural language processing, speech, supervised learning, and unsupervised learning (Properzi & Cruz, 2020). Machine learning is a subset of AI and

defined as a specific study of computational models and algorithms on the computer using experience based on historical data to progressively improve the performance of a specific task or make the predictive analysis more accurate (Sharma et al., 2020b). One of the AI's advanced branches, robotic process automation, can increase productivity by 20% (Dash et al., 2019). The percentage of enterprises implementing AI grew 270% in the past four years, and global spending on machine learning and AI is forecasted to grow from $40 billion to $98 billion by 2023 (Zemankova, 2019). AI is deployed to analyze information in real-time, monitor information across the globe, predict the future with a minimum error rate, and adjust to rapidly changing environments (Calatayud et al., 2019). AI powered technologies in the pharmaceutical supply chain helps in end-to-end visibility to supply chain managers. AI helps in demand forecasting, automation, optimizing the predictive maintenance, and also toward protecting the integrity of pharmaceutical supply chain from counterfeit drugs.

Demand forecasting, which allows managers to plan and provides an estimate of future demand based upon historical data and the current state of the political, social, and economic environment, is one of the most critical elements of pharmaceutical SCM (Merkuryeva et al., 2019). AI enabled supply chain system helps business managers in optimizing the key performance indicators, review in real time, cut cost, reduce waste, and speed time to market (O'Reilly & Binns, 2019). Klumpp (2018) found that AI enabled system helps business managers across the globe allow interconnected, agile, and collaborated value chain, which can adapt almost instantly to change in demand and the

evolution of regulation and technologies.

Dash et al. (2019) found that AI needs to be implemented in the supply chain road map to gain the competitive advantages with the improvement of metrics, such as the accurate projection and forecast the customer demand, reduction in the cost of inventory quantity, overproduction, idle machine capacity, achieving quick reaction to the change in the market, and finally providing customers a better experience. AI technologies have enabled computer's thoughts by providing a conceptual framework for processing inputs and making a decision based on that data (Dash et al., 2019). Series of algorithms and dataset enables the AI system to integrate supply chain business toward (a) getting 100% accurate projection and forecast customer demand, (b) optimization of R&D by enhancing the quality and reducing costs, (c) identifying target customers and demography, and (d) providing a better customer experience. AI technologies help business managers in eliminating waste, smart manufacturing, transparency on supplier machine availability, performance, downtime, balancing the supply chain, and optimize inventories in real-time (Kusiak, 2018).

Application of AI can enhance value creation in supply chain process, such as (a) forecast demand and optimization, (b) smart manufacturing, and (c) delivery (Dash et al., 2019). Pharmaceutical organizations are always looking for balanced and optimized demand and supply chain tools. Applying AI and machine learning toward using the right strategies to the right products and reducing latency can enable an organization to respond to supply chain visibility more effectively (Klett, 2020). The business managers

can take AI help in processing, analyze, and predict data toward providing accurate and reliable forecasting demand allowing businesses to optimize their sourcing regarding purchases and order processing, therefore, reducing the cost to supply chain processes (Dash et al., 2019). Klett (2020) further found that the area of potential improvement in supply chain processes from AI lies in automating business processes, generating and validating correct forecasts, managing changes by implementing recommended actions, and mitigating risks. Dash et al. (2019) further suggested that AI can help in smart manufacturing by preventing downtime for maintenance and, therefore, improve quality and reliability. Few organizations are now using intelligent process automation, which combines robotic process automation and machine learning to deliver powerful algorithms to mimic human interactions and make advanced decisions (Properzi & Cruz, 2020). Innovative AI technologies help pharmaceutical industries enhance drug discovery processes, reduce the research effort, and maintaining the future sustainability (Agrawal, 2018; Donzanti, 2018).

Cloud-Based Supply Chain (Cloud Computing)

The production and delivery of products and services in a timely fashion with short lead time and less cost are critical supply chain objectives of many organizations, but unfortunately, many are not able to achieve this with the traditional non-responsive traditional supply chain technology they have (Giannakis et al., 2019). Cloud computing offers on-demand computing services with high availability, reliability, and scalability. Cloud computing can provide organizations with a significant amount of power with

computing and storage and help them deliver services at far cheaper rates that were earlier unaffordable (Ross & Blumenstein, 2015). Many pharmaceutical organizations are now adopting cloud-based infrastructure for their supply chain processes. Organizations can achieve many benefits by implementing a cloud-based supply chain, such as real-time end-to-end supply chain visibility, the collaboration between organizations, capturing disruption risks, and creating a knowledgeable learning community for optimizing decision making (Giannakis et al., 2019). Cloud can be useful for both clinical and supply chain cycles, and globally pharmaceutical industries are using cloud technology as their business model. The use of cloud computing helps supply chain organizations to reduce cost, response time enhancements, delivery time, and increase supply chain visibility. Cloud SCM is placed at the core of business processes with estimated to arrival, estimated to departure, and the actual time of departure is continuously being updated using GPS installed in trucks. Projected availability of raw material can be forecasted correctly, and updated manufacturing information of scheduling, work in process, completion, and shipping confirmation of final product to the partners (Giannakis et al., 2019).

Supply chain responsiveness is defined according to several dimensions, such as customer sensitivity, demand transparency, supply chain response lead time, agility, flexibility, and information sharing (Giannakis et al., 2019). Cloud-based information sharing improves the supply chain visibility in the healthcare supply chain and improves the supply chain responsiveness. Scalability and flexibility are a significant factor in

driving cloud computing use in the supply chain area. However, despite the potential cloud benefits in the supply chain, organizations are reluctant to adapt primarily because of security breaches between partners and data loss that cannot be replaced (Cao et al., 2017).

BDA

Business managers from the pharmaceutical companies face stringent quality standards globally, inorganic growth regarding mergers and acquisitions, and massive information coming from stakeholders, and they must manage these efficiently. The digitalization concept introduced new challenges in capturing, collecting, analyzing, archiving, sharing, transferring, and processing large data set in the organizations (Onciou, 2019). Big data is defined as data generated continuously in diverse data formats (structured and unstructured) from multiple sources (Grover et al., 2018). BDA may help the business managers by providing a new perspective and add value toward improving modeling practices and predictive analysis (Onciou, 2019). Analyzing the vast amount of data from various sources can help organizations reduce costs, understand the customer better, and better manage their supply chain uncertainties (Vidgen et al., 2017).

The digitalization advances in the SCM led to a significant increase of data to get a clear picture of customer needs, and BDA can significantly contribute to areas such as product development, market demand predictions, distributing channel optimization, and customer feedback (Onciou, 2019). BDA works on predictive analysis principles. Predictive analysis is based on real-time data analysis and historical data to predict the

likelihood of future events (Onciou, 2019). Predictive analytics uses statistical techniques and forecast models to predict insight into the future using historical past data (Nagarajan & Babu, 2019).

BDA in the supply chain can help improving supply chain performances by improving visibility, resilience, robustness, and organizational performances (Gunasekaran et al., 2017). BDA can give rise to an intelligent supply chain as many business advantages can be achieved through big harvesting data, including higher operational efficiency, better customer services, better informed strategic directions, and identifications of new markets, customers, products, and services (Zhan & Tan, 2020). Big data helps create business insights for delivering value, performance, sustainability. A typical data classification method is 5V's (volume, velocity, variety, value, and veracity). The volume represents the ever-growing magnitude of data; value indicates the continuous generation of fast-paced data; the third characteristics variety is different data of format; value refers to the hidden insight in data; and veracity refers to the noise, biases, and trustworthiness in data collected (Grover et al., 2018; Yaqoob et al., 2016). Big data predictive analysis can also help in responding faster to changing and volatile supply chain environments, providing more power in supplier relationship, enhancing sales and operation planning, reducing supply chain cost, ensuring on-time delivery to customers, and most importantly, enhancing supply chain cost (Gunasekaran et al., 2017). BDA is reported to be an emerging digital supply chain game-changer enabling organizations to meet and excel in the dynamic and fast-paced competitive global market

(Nguyen et al., 2020).

The supply chain operating reference model incorporating SCM, and big data portrays different pillars, such as planning, sourcing, making, and delivering, which involves the flow of finance, material movement, and information flow to integrate demand and supply management across the supply chain framework (Raman et al., 2018). BDA helps business managers make a significant contribution toward handling demand management efficiently and providing a greater customer satisfaction level (Raman et al., 2018). BDA is an opportunity to use new types of data to create more agile businesses to solve problems, which was previously considered unsolvable in supply chain framework, leading to better business results (Onciou, 2019). The supply chain operating reference model incorporates supply chain cycles, such as planning, sourcing, making, delivering, and return.

Enterprise Resource Planning

The feature of industry 4.0 revolution is the integration of digital technologies, such as IoT, AI, big data, and enterprise resource planning (ERP) in order to improve connectivity chain within the supply chain environment (Tongsuksai & Mathrani, 2020). Application of ERP in the supply chain may help pharmaceutical managers in area, such as streamlining end-to-end planning, supporting transportation and inventory keeping in warehouses, providing more visibility on analytics using which better decisions can be made. ERP applications are integrated information system packages that integrates the business functions of an organization into once core application and enable the

organization to operate seamlessly by sharing the same information across (Albarghouthi et al., 2020). ERP applications are tools that help supply chain managers make managerial decisions and provide visibility throughout the organization. ERP application may help bring many disintegrate and standalone systems into one application to create a synergistic environment within the organization. Cloud ERP system that evolved from the on-premises ERP systems helps organizations to achieve higher efficiencies and lower operational costs (Tongsuksai & Mathrani, 2020). Cloud ERP system with new digital technologies based upon industry 4.0 revolutions can help organization in veracious metrics, such as (i) informed information flow and real time data for easier decision make, (ii) real time tracking management for real time inventory and smart purchasing, (iii) to collect and provide real time data from suppliers to end users which can be sued for analyzing and deploying toward enhancing and improving operations through prompt feedback, (iv) flexibility to reach up to date demand sensing, (iv) improve quality by removing error in supply chain processes and reducing wastage, and (v) reducing product and labor costs by recognizing nonconforming products in the early phase of supply chain processes (Tongsuksai & Mathrani, 2020).

Disruptions and Agility in the Digital Supply Chain

Lasch (2018) defined supply chain disruptions as a singular or combination of unexpected events, such as fire, flood, accidents, and supplier bankruptcy, that interrupts the flow of goods and services and negatively influence SCM processes. Supply chain processes in pharmaceutical organizations are inherently risky and may not avoid

disruptions. The management of pharmaceutical companies must create a strategy to mitigate supply chain disruption risk for improving the firm's operational performances. Supply chain disruptions could also be an outcome of supply chain activities, including (a) outsourcing, (b) technology innovations, (c) reduction in inventories, and fluctuations in demand (Kovács & Falagara, 2021). Outsourcing of digital enabler maintenance to an external player may create a severe issue in unpredicted events. The current coronavirus disease constitutes a global pharmaceutical supply chain crisis, and as per estimation, the epidemic, will on average, cause an economic loss of 0.7% of global GDP (Kovács & Falagara, 2021). Pharmaceutical organizations rely heavily on suppliers for raw materials, contract manufacturers, and logistics service providers to distribute products worldwide. Dependency on a single supplier and lack of financial support for the vendor account payable may adversely affect the organization. Supply chain risk strategies are a vital element that pertains to successful implementations of digital strategy while dealing with unexpected disruptions. Agility, flexibility, and leanness may reduce the effect by minimizing the likelihood of disruptions (Eltawy & Gallear, 2017; Mohammaddust et al., 2017).

Supply chain agility is the firm's capability to respond to unforeseen changes in customer needs, ever-changing demand, and competitor's moves in the dynamic global business environment (Gupta et al., 2019). Agility helps respond to changes by adapting its initial state configuration and is also identified as an antecedent, driver, and enhancer of supply chain resilience (Kamalahmadi & Parast, 2017). Agility is a critical strategic

element and acts as an enabler of responsiveness by facilitating quick response to unforeseen events**.** Skill is now applied to the whole supply chain as a way of doing business (Eltawy & Gallear, 2017). The concept of supply chain agility is defined by emphasizing a pharma manufacturer's capability to sense the change and then rapidly respond by reducing lead time, enhancing the level of customer services, and improving delivery reliability (Shekarian et al., 2020). Kamalahmadi and Parast (2017) revealed two components of agility in the context of supply chain resilience: visibility and velocity, which is the loss that happens per unit of time during disruptions.

Sustainability in the Digital Supply Chain

Sustainability is protecting stakeholders' interests by focusing on non-financial environments, such as environmental, social, ethical, and governance, by accomplishing the financial performance and creating stockholders' s value (Zabihollah, 2021). Maniora (2018) described sustainability that meets the present's need without compromising environmental generations to meet their own needs. As defined by the triple bottom down sustainability theory, supply chain managers must consider social, economic, and ecological objectives while deciding to make their business profitable (Sivarajah et al., 2020). Sivarajah et al. (2020) further stated that organizations must give back to the communities they operate and must take initiatives to replenish and conserve natural resources to provide services and manufacturing tangible products. Each of sustainability is discussed in detail, starting with environmental sustainability.

Globalization has prompted organizations to build highly interconnected and

complex supply chains. As a result, companies adopt the outsourcing model to outsource non-core activities to overseas suppliers without much consideration. The shift toward outsourcing and waste and emission caused by production processes throughout the global supply chain is the primary source of environmental issues (Ashby, 2018). In current operating model, there have been an increase in third-party logistics and transportations (TPL) providers who were outsourced to serve the developing countries' supply chain. El Baz and Laguir (2017) concluded that major challenges to environmental sustainability in developing countries include a serious lack of collaboration between third-party logistics providers, a lack of governmental regulations for environmental standards, a lack of environmental policy initiatives and commitment by management, and a relatively immature stage of economic development in developing countries.

The need to coordinate activities between supply chain partners to satisfy environmental regulations imposed by governmental legislation and the requirement to improve the company's environmental profile for their potential customers are now deemed necessary for the organizations (Zissis et al., 2018). The manufacturing processes may consume energy and materials and, in the process, release waste also in the ecosystem. Even the global supply chain's transportation process may adversely impact the environment regarding energy used and discard pharmaceutical raw material mismatch at source and destination. Nowadays, end customers are demanding eco-friendly products and services that do not damage the environment (Green et al., 2019).

The demand from intermediate and end customers is now pushing manufacturers to rebuild or modify their operations. Ashby (2018) suggested using the closed-loop supply chain by taking example from the clothing industry, where the local firm, customers, and global suppliers coordinate in a way that follows appropriate environmental practices by initiating the reverse flow of used clothing toward maximizing the value and minimizing the waste in global supply chain lifecycle. Alzaman et al. (2018) noted that implementing green SCM will improve environmental performance regarding fewer carbon footprints and help the competitive advantages and economic performance of an organization.

Social sustainability in the supply chain also plays a substantial role, as supply chain managers and partners must address stakeholders' needs and human capital to achieve long term sustainable results. Socially sustainable supply chain practices are defined as introducing a range of initiatives, including protection against child and slave labor, health and safety programs for employees, outreach to communities, and supporting human rights (Croom et al., 2018). Gouda and Saranga (2018) found that organizations have adopted social and environmental sustainability practices to reduce their carbon footprints and improve their image on the social front. Sodhi and Tang (2018) suggested that organizations that adopt sustainable practices in their supply chain processes outperform their competitors in stock market performance and financial metrics.

Transition

The intent of this qualitative multiple-case study was to explore the strategies

used by some pharmaceutical managers to digitalize the integrated supply chain system to increase their profitability. I planned to use the conceptual framework of TOC to discover the participant's strategies to address the research problem identified in Section 1. I presented the problem and objective of this study to explore the strategy, the conceptual framework, the study's significance, the potential social impact, and a review of professional and academic literature to support my research study. In Section 2, I provide a rationale for the selected research method and approach for this study. In Section 3, I presented the findings, the application to professional practice, the implications for social research, the recommendations for further research and action, reflections on my experiences within the Doctor of Business Administration doctoral process and ended with a conclusion.

Section 2: The Project

In Section 2, I discuss the design, rationale, and explanation of the qualitative method used in this study by restating its purpose. Section 2 also includes a detailed presentation of the sampling, population, data collection, data analysis, and the study's reliability and validity.

Purpose Statement

The purpose of this qualitative multiple case study was to explore the strategies used by some pharmaceutical managers to digitalize the integrated supply chain system to increase their profitability. The target population consisted of five managers from four pharmaceutical companies in New Jersey who have successfully developed strategies to digitalize the integrated supply chain system to improve their business practices and profitability. The study findings may enable pharmaceutical managers to identify and implement value-added strategies to digitalize their supply chain system, which could help reduce operating costs, improve profitability, and contribute to national, state, and local economies. Pharmaceutical managers could also facilitate increased availability and distribution of noncounterfeit medicines to patients at lower prices to effect positive social change.

Role of the Researcher

A researcher serves as one data collection method, becoming an instrument in qualitative research (Wa-Mbaleka, 2020). A researcher acts as the primary instrument to collect and manage the data, evaluate and organize the data, analyze data, and arrive at a

conclusive end (McKenna et al., 2017). As a researcher, my role included designing the interview protocol for this study, selecting the research design and methodology, choosing a conceptual framework, selecting participants, collecting data using semistructured interviews, and analyzing and evaluating the documents and data collected from interviewed participants. I followed the established interview protocol to ensure consistency and trustworthiness across each of the participants I interviewed for this study (see Appendix A). As a sole researcher and serving as a primary research instrument in the qualitative study, I was responsible for the interview process involving how pharmaceutical companies' supply chain managers develop digital strategies to create profitability.

Another part of a researcher's role is their experience, which a qualitative study's accuracy depends on (Bernard, 2013). I am an experienced executive with over 27 years of industrial experience. I earned a bachelor's degree in engineering with a master's in business administration and a master's in management. I am a certified project and program manager and lead the global supply chain in my organization. I applied my skills and experience as part of this research study by gathering the information about my research question.

Because the researcher is the primary instrument of the study, it is also important to remain bias free (Dikko, 2016). It is essential to mitigate bias to reveal the participants' true feelings without distortion (Cypress, 2018). To mitigate bias, I reviewed the transcripts, conducted bracketing, and engaged in reflective thinking to double-check for

any instances for possible biases. I ensured that my personal experience did not bias the process while I collected and interpreted data. I prepared a complete list of my biases in advance in my reflective journal before conducting my interviews. The list included possible biases such as researcher biases and participants biases. Member checking was another method I used to identify my own biases during data collection, interpretation, and results of this study.

The *Belmont Report* (National Commission for the Protection of Human Subjects and Biomedical and Behavioral Research, 1979) also suggests that research should ensure respect for persons, beneficence, justice and avoid exposing participants to undue physical or psychological harm. The interviews were held and recorded using Zoom to avoid exposing participants to undue harm during COVID, whether physical or psychological, following the *Belmont Report* guidelines (National Commission for the Protection of Human Subjects and Biomedical and Behavioral Research, 1979). As a researcher, I followed the *Belmont Report*'s ethical guidelines, including the confidentiality of participants concerning handling the responses.

Participants

The participants must have the relevant experience and knowledge required for enhancing the data collection and analysis of the qualitative research (Yin, 2018). The eligibility criteria for selecting the participants for this multiple case study included business managers who have successfully implemented digital supply chain strategies in their organizations. Participants had accountability to manage the digital supply chain

system in their organizations. These managers were knowledgeable in the digital strategy, daily supply chain operations, practices, processes, challenges, and pain points of the traditional linear supply chain compared to an integrated digital supply chain system.

In multiple case studies, researchers must have access to potential participants (Yin, 2018). Recruitment began after approval from Walden University's Institutional Review Board (IRB). I performed searches from a pharmaceutical companies' databases in New Jersey using a publicly available domain from biopharmguy.com. I also performed searches on peer reviewed SCM journals, LinkedIn, and information gathered from company websites to narrow down the companies, which were good candidates based on digital supply chain performances. I reached out to supply chain managers of those companies who successfully managed digital strategies in supply chain operations and found five participants who were willing to participate in this study. I did not need to contact their companies regarding the participants' willingness to participate in this study on their own time. I sent consent forms to the study participants via email and requested participants to respond with the words "I consent" to my email. They replied to my e-mail stating "I consent." In adherence to the ethical guidelines, I reviewed the information in the consent form with participants, including their rights to withdraw from the participation at any point without any risk or fear from repercussions. I also reviewed the purpose of my research and the interview questions.

The relationship between the researcher and the participants is important. Researchers must develop an excellent working relationship with participants to execute

the study (Yin, 2018). I followed the best practices for credible qualitative research by explaining the objective and process of the study to the participants and obtaining their buy-in to participate in the study. Prospective interview participants were sent an invitation letter and consent form. I then established a working relationship with participants by talking to them over the phone and engaging in meaningful conversation about the objective of the research. The participants fully understood their rights through the informed consent notification before signing the consent form. The participants participated voluntarily, and they had the option to withdraw at any time before starting or during the interview. Voluntary participation might decrease the response rate (Marshall & Rossman, 2016). Still, the likelihood of honest response may increase because the individuals who willingly submit responses feel less pressure to fabricate answers.

Research Method and Design

I used a qualitative method to explore the strategies used by pharmaceutical managers to digitalize the integrated supply chain system to increase their profitability. I used a multiple case study design to support my research, including the target population of five managers from four pharmaceutical companies.

Research Method

Three types of research studies are quantitative, qualitative, and mixed (Yin, 2018). The research methodology and design flow from the type of research needed to support my work in addressing the research question as used in this study (Marshall &

Rossman, 2016). Developing generalizable rules and verifying hypotheses' falsification is the focus of the quantitative research method (House, 2018). The quantitative method did not meet the requirement of this study, as I did not test theories or hypotheses to examine the strategies used by pharmaceutical managers. Qualitative researchers explore a phenomenon where little understanding of the subject phenomenon exists (Schoonenboom & Johnson, 2017). Using a qualitative method, researchers may develop a deep understanding of the various pain points associated with their current supply chain systems. The mixed method combines both quantitative and qualitative research elements. Using a mixed method, the researcher uses quantitative and qualitative methods to apply pragmatic, deductive, inductive, and predictable approaches for developing an understanding of generalized findings (Schoonenboom & Johnson, 2017). The mixed method design did not meet the criteria because I did not use the quantitative method.

Research Design

Four possible qualitative study designs include phenomenology, narrative, ethnography, and case study. Researchers select a phenomenological design to study participants' lived experiences with the phenomenon to understand the problem studied in research (Daher et al., 2017). The phenomenological design may also involve excessive participant–researcher engagement in a series of interviews, developing rich data, patterns, and themes (Sohn et al., 2017). I did not need extensive engagement with the participants because my research was focused on digital strategies as implemented by pharmaceutical managers and not lived experience about a specific phenomenon.

A researcher using narrative research explores the complexities of the human experience regarding a story or nuances of personal experience (Nolan et al., 2018). I did not select a narrative study because I was not exploring a personal experience nor gathering a written narrative. I used face-to-face interviews to develop an understanding of the research problem.

In ethnographic research, the researcher studies the behavior, perception of a population within their environment and explores patterns among peoples to understand a research phenomenon (Creswell & Poth, 2018). An ethnographic design was not appropriate for my research study. I did not explore the culture of a small group of pharmaceutical managers' digital strategy.

I used a multiple case study design to explore the patterns and themes that pharmaceutical managers use to digitalize their integrated supply chain systems. A case study strategy enables researchers to perform an in-depth inquiry into a topic to generate insights in a real-life context experience (Yin, 2018). Researchers also use the case study to identify the made and implemented decision, which yielded specific results (Yin, 2018). A single case study design is more appropriate when researching a unique case to explore a problem in a single industry case (Laurin & Fantazy, 2017). A multiple case study was more suitable to explore strategies used by pharmaceutical managers to digitalize their integrated supply chain system.

Researchers achieve data saturation when interview responses become redundant and is achieved using sources, including interviews, documentation records and reviews,

and observations (Saunders et al., 2019). I reached data saturation when responses to questions failed to provide new information. Interview of five managers from four different pharmaceutical organizations helped me to reach data saturation. The depth and richness of data will determine data saturation and not solely the population's sample size (Fusch et al., 2018). Data collection from each organization was used to compare trends, patterns, and emerging themes.

Population and Sampling

A study population is the number of people within the organization eligible for sampling consideration (Yin, 2018). This qualitative multiple case study's target population included five managers from four pharmaceutical companies in New Jersey that have successfully developed strategies to digitalize the integrated supply chain system to improve their business practices and profitability. Having experts in the study often offers the best results (Martínez-Mesa et al., 2016). Therefore, my goal was to find eligible and qualified candidates in the SCM who are in the same role for at least 5 years and successfully implemented digital supply chain strategies in their organizations.

I performed searches from a pharmaceutical companies' databases in New Jersey using a publicly available domain from biopharmguy.com. I also performed searches on peer-reviewed SCM journals, LinkedIn, and information gathered from company websites to narrow down the companies, which were good candidates based on digital supply chain performances. I reached out to supply chain managers of those companies who successfully managed digital strategies in supply chain operations and found five

participants who were willing to participate in this study. I did not need to contact their companies regarding the participant's willingness to participate in this study on their own time. I obtained authorization from Walden University's IRB to obtain consent from potential candidates to participate (approval number 07-16-21-0985037).

Researchers often use four sampling strategies for the multiple case study, which are purposive sampling, probabilistic sampling, nonprobabilistic sample, and census sampling (Marshall & Rossman, 2016). The participants had the chance of being selected for the study in the probabilistic sample, but in nonprobabilistic sampling, researchers can be biased in the selection process because the participants are not randomly selected (Peregrine, 2018). Census sampling is time-consuming since the researcher must interview the participants from the population, and data analysis may also take some time (Marshall & Rossman, 2016). Purposive sampling, rather than a random sample, was better suited for this study because it provides a more robust test of external validity based on the researcher's subjective considerations (Ames et al., 2019). Purposive sampling is used when a particular phenomenon is studied in a specific context (Yin, 2018). The study sample must be representative of the population. Because this study was set in a specific SCM function within the pharmaceutical industry, purposive sampling was used to select participants for the study.

Interview protocol and the interview questions, as shown in Appendix A, were sent to participants before the interview. I digitally recorded and transcribed the data to facilitate the reliability of the data. The participants were also asked additional questions

if needed to confirm the accuracy or obtain further information.

Researchers achieve data saturation when interview responses become redundant, which is done through using sources including interviews, documentation records and reviews, and observations (Saunders et al., 2019). The depth and richness of data will determine data saturation and not solely the population's sample size (Fusch et al., 2018). Interview of five managers from four different pharmaceutical organizations helped me to reach data saturation.

Ethical Research

When conducting a field research study, an informed consent document is required to protect study participants' rights, especially when human beings are part of study as mandated by ethical and federal regulatory agencies (Yin, 2018). The informed consent document comprised specific details, such as the objective of the research, associated risk and benefits, compensations and costs, the term of compliances, voluntary involvement, and withdrawal (see Wilson, 2014). Informed consent should help transparency research and protect the participants (Yin, 2018). I sent consent forms to the study participants via email and request participants to respond "I consent" to my email should they agree to participate in this research study. The researcher must ensure they follow informed consent rules, including obtaining study participants' consent to the research, the flexibility to withdraw at their discretion, receive confidentiality and protection, and face no risk pertains to their participation (Bromley et al., 2015). In adherence to the ethical guidelines, I reviewed the consent form with participants,

including their rights to withdraw from the participation at any point without any risk or fear from repercussions. I also informed them not to receive any financial incentives for voluntary participation in the study. I followed the established interview protocol to ensure consistency and trustworthiness (see Appendix A).

IRBs are the regulatory committee for overseeing human subject research (Blackwood et al., 2015). The IRB scrutinizes the ethical quality that a researcher applies to the research process. The researcher must submit details of their studies, including particulars about participant selection, which the agency analyzes for any possible exception. The IRB approval includes specific criteria, including the rationale of risk versus benefits, minimizing or completely removing risk, participant's confidentiality, ethical subject selection, documentation, and voluntary consent (Blackwood et al., 2015). I addressed any possible ethical issue by (a) maintaining transparency in throughout this study process, (b) informing my participants by using the informed consent and participants replied to an email with "I consent," (c) I also followed the interview protocol, that provided instructions for the data collection process for this study. Spillane et al. (2017) noted researchers often utilize pseudonyms for maintaining the confidentiality of participants. I protected participants' real identities by providing pseudonyms to my participants and their company. I also secured the research data in a locked drive in my home office for 5 years. I will erase the research data from the hard disc after 5 years.

Data Collection Instruments

I was the primary data collection instrument for this study because of my direct involvement in data gathering and data interpretation. The researchers are the primary data collection instrument in qualitative research (Cypress, 2018). The researcher is the primary data instrument because they have firsthand experience with the research subject, participates in the hearing, seeing, and interpreting the data (Marshall & Rossman, 2016; Yin, 2018).

I have used semistructured interviews as the primary data collection source. Interviews are a primary data collection source for a qualitative multiple-case study (Yin, 2018). Documentation, achieved records, interviews, direct observations, participants' observations, and artifacts are six sources of data collection and evidence in a case study (Yin, 2018). I also reviewed the company's publicly available information as the additional and secondary source in data collection processes. Publicly available information may contain details on the Internet and include success stories of digital supply chain transformations, visibility, and corporate profit by adapting digital tools in operations.

Semistructured interviews involve asking the same set of questions from each participant, allowing more flexibility, and keeping the interview on track (Wilson, 2014). Semistructured interviews are more organized, and the research topic guides the conversation in a standardized manner to allow relevant issues to emerge. Semistructured interviews are an effective way to collect data from participants having different views on

the same subject (Yin, 2018). Each semistructured interview should take one hour to complete, and I will try to achieve it in the allocated period. The interview protocol includes the interview questions and the steps for conducting the interviews. The steps are to (a) collect the informed consent form before scheduling the interview, (b) introduce myself at the start of the interview, (c) asking permission for recording the interview, (d) ask the interview questions, and finally thanks to the participant for the participant in this study. I also utilized an interview technique to develop the results' validity and reliability from a collection of data from multiple sources. I asked open-end questions (see Appendix B) to explore the digital strategies business managers used to digitalize their supply chain systems.

Member checking or participant validation is when the final interpretation of the interviews is shared and reviewed with the participant to ensure that data was correctly interpreted (Birt et al., 2016). I followed up with the participants to schedule a second meeting for member checking, which took approximately 30 minutes. Member checking allows the participants to make changes, provide additional information, and possibly ask and clarify more information about the study (Birt et al., 2016). The process of member checking benefits the researcher by improving the study's reliability and validity. I followed up with all participants within 3 to 6 days to schedule a second meeting for member checking, which took approximately 30 minutes.

Member checking and triangulation enhanced the reliability and validity of the data collection processes of this study. Fusch et al. (2018) explained that methodological

triangulation provides rich and accurate data and correlation in the data, thereby fostering the understanding of the research phenomena and enhancing the research's validity. I used an interview protocol (see Appendix A) consists of interview questions, interview reminders, and pre- and post-interview activities. Yin (2018) stated the interview protocol is used as a guide to enable consistency, maintaining order, and ensuring that participants understand their rights. I used the within-method type of methodological triangulation to analyze data collected during the semistructured interviews and document analysis.

Data Collection Technique

The research question for this qualitative research study was "What strategies do pharmaceutical managers use to digitalize their integrated supply chain system to increase profitability?" I performed searches from a pharmaceutical companies' databases in NJ using a publicly available domain from biopharmguy.com. I also performed searches on peer reviewed SCM journals, Linkedin.com, and information gathered from company websites to narrow down the companies, which were good candidates based on digital supply chain performances. After receiving IRB approval from Walden University, I used the purposive sampling design recommended by Tobi and Kampen (2018) to focus on a particular phenomenon to identify participants based on my eligibility criteria to participate in this study. The eligibility criteria for selecting the participants for this multiple-case study included business managers who have successfully implemented digital supply chain strategies in their organization. The researchers in qualitative studies aim to explain a phenomenon in a specific context use a

purposive sample design (Sovacool et al., 2018; Tobi & Kampen, 2018). I reached out to supply chain managers of those four companies who successfully managed digital strategies in supply chain operations and found five participants who were willing to participate in this study. Prior to each interview, I emailed each participant an invitation to participate in this study with a consent form attached to the email and asked if participants agreed to participate in this study. I asked them to respond to my email with the words "I consent." Once I received consent from each participant, I scheduled Zoom video conferencing interviews with the participants. Before each interview began, I asked all participants for their consent to record the interviews using the Zoom application installed on my iPhone mobile phone. The participants participated voluntarily and without any compensation. They had the option to withdraw at any time before starting or during the interview.

Semistructured interviews helps a researcher to provide in-depth and actual research inquiries and supporting the researcher in allowing him or her to ask why and how questions (Yin, 2018). Interviews, organizational documents, physical artifacts, questionnaires, observation during the field, and document analysis were primary data collection tools in qualitative studies (Yin, 2018). I collected data directly from pharmaceutical managers in semistructured interviews, observations, documentation shared by participants, and documentations open to the public on websites. The primary data collection I used was semistructured interviews guided by the interview protocol (see Appendix A). Using semistructured interviews with well-informed and

knowledgeable informed participants helped me openly interact with participants for rich data, thick descriptions, and credible information. However, participants may be subjected to inaccurate articulations, poor recall, and bias (Yin, 2018). I shared the interview questions well ahead of the interviews using emails upon receiving informed consent from participants (See Appendix B). Documents such as best practices, standard operating procedures (SOP) may help researchers discover underlying themes (Yin, 2018). I requested my participants to provide me with any supporting documentation to collaborate with the interview questions' data. I received supporting documents, such as digitalization project success stories, standard operating procedures for using digital tools, and best practices for digitalizing supply chain operations from participants. I also reviewed documentation as available public information on websites.

Researchers are advised to inform the participants of the time, place, scheduling, and duration of the interview to adjust their schedule to avoid any potential disruptions (Peticca-Harris et al., 2016). I decided to conduct interviews through video conferencing to accommodate for certain COVID-19 restrictions. I scheduled calls with the participants to conduct an interview using Zoom meeting app. Upon receiving permission from the participants, I recorded the semistructured interviews to avoid misinterpretation using the Zoom application installed on my iPhone mobile phone. Researcher must ensure that the interview's place and time must be convenient for the participants and allow adequate time to complete the interview (Dikko, 2016). I conducted a 60-minute face-to-face video interviews using Zoom to make the experience more personable and comfortable while

observing their body languages and responses. I emailed each participant to agree on the time and duration of the interview convenient for them. I was flexible to accommodate any of their requests to change the interview time or date and rescheduled two interviews based upon participant's requests. The background noises that disturb or distract participants and interfere with audio recordings potentially impact the data collection processes (Dikko, 2016; Seitz, 2016). From my side, during the zoom calls, I ensured that there were no disruptions that would interfere with the interview processes. I also observed no background noise or any distraction from any of the participants.

Triangulation and member checking enhance reliability and validity. I triangulated my findings through interviews, analysis of documentations shared by participants, and analysis of documentations open to the public on websites. Triangulation helps researchers authenticate the information from multiple sources pertains to the same events toward increasing the study's validity and reducing bias (Fusch et al., 2018). Triangulation helped me reduce bias and increase this study's reliability and validity. I also used my reflective journal to help with data triangulation. Member checking is another method I used to identify possible bias in the interpretation and results. Member checking allows participants to take part in the research process by researchers giving participants the ability to fact check and authorize the researcher's interpretations of the data provided by the participants, which helps increase research credibility and validity (Iivari, 2018). During the interviews, I interpreted their response and asked them through member checking if my interpretation was accurate, wherever I

needed to clarify a participant's response. I transcribed the recorded interview using Otter, and the interview transcripts were shared with participants for their review on a zoom call to confirm the accuracy of the transcription. The participants were in agreement that no changes were needed. I used the original transcripts for my data analysis.

Data Organization Technique

Data organization helps researchers manage and retrieve the collected data toward improving the quality of their research study and enhancing the trustworthiness of the research (Marshall & Rossman, 2016). For meeting the objectives of the study, the following information were collected: (a) informed consent; (b) recording of semistructured interview captured using the Zoom application installed on my iPhone mobile phone; and (c) documentation shared by participants pertains to their experience while implementing digital tools and technology in SCM. I maintained a reflective journal to document dates, keywords, non-verbal cues, and other observations about each interview. I followed potential researcher bias, as recommended in the bracketing process proposed by McNarry et al. (2019). I ensured that my personal experience did not bias the process while I collected and interpreted data. I ensured to prepare a complete list of potential biases of participants and researchers in advance in my reflective journal before conducting my interviews.

I stored the documents in a password-protected hard drive at my home office for 5 years. Participants must be protected from any harm, and their confidentiality should also

be ensured and respected by researchers (Ennever et al., 2019). I replaced the participants' actual names with coded names, such as P1, P2, P3, P4, and P5, and O1, O2, O3, and O4 replaced the name of their organizations. I ensured that their name and organization names do not occur while transcribing the data. As required by Walden, after 5 years of elapses, I will destroy the hard copies of collected data using the shredder and soft copies by deleting from my hard disk.

Data Analysis

Data analysis is the process for a researcher to identify and compare critical factors amongst multiple data sources (Marshall & Rossman, 2016). Bengtsson (2016) noted that performing data analysis is used to organize the collected data, identify the themes, and draw a logical conclusion. For data analysis, I used thematic analysis and clustered the themes with documentary evidence as to how they related to my conceptual framework of the TOC and organized them alphabetically. The TOC framework helps researchers in providing the insights needed to determine why non digitalized SCM fails to achieve organizational goals. Constraints hamper the progress or increase productivity losses within the organization. The pharmaceutical manager's failure to manage these constraints leads to declines in its productivity. The same TOC analogy can be made to the supply chain, where weak and nondigitalized supply chain links can limit the entire supply chain's efficiency and effectiveness. A digitalized supply chain system can have various constraints, such as constraints related to storage, constraints related to production, constraints related to flow, and constraints related to strategic partners'

information (Okutmus et al., 2015). The TOC method was used to anticipate and address the primary challenges companies face and utilize to develop their digital road map. Using TOC conceptual framework, I was able to understand the strategies, processes, and tools the participating pharmaceutical managers used to digitalize their supply chains successfully.

I followed Yin's (2018) five-steps process of the thematic analysis of codes and patterns of collected research data. Yin (2018) explained the process as (a) gather and compiling the research data, (b) first disassemble the data, (c) then reassemble the data, (d) interpret the data collected, and (e) finish the process by concluding the data. The collected data were processed and analyzed using ATLAS.ti data management software to organize the collected data. Data management software programs can help qualitative researchers in data compilation, code similar themes, and interpret relationships among codes (Yin, 2018). I used ATLAS.ti software to compile, disassemble, reassemble, interpret and concluded the finding suggested by Yin (2018) five step data analysis.

I used the Zoom application of my mobile phone for the initial transcript of the interviews. With the Zoom application's help, I audio recorded the interview and converted it into a transcript output. Sovacool et al. (2018) found that the objectives of content analysis are to systematically identify themes and patterns by coding documentation and interview transcripts. I performed the content analysis by using deductive coding and then identified themes in ATLAS.ti. ATLAS.ti helped to organize the collected data, maintaining a list of codes, and identifying themes (Bengtsson, 2016;

Yin, 2018).

Methodological triangulation is the process of validating information retrieved by multiple sources of data about the same event toward decreasing bias and enhancing the research study's validity (Fusch et al., 2018). Methodological triangulation involves viewing a phenomenon using data collected from multiple methods. I used a methodological triangulation approach for triangulating data received from interviews. I received supporting documents, such as digitalization project success stories, standard operating procedures for using digital tools, best practices for digitalizing supply chain operations from participants. I also reviewed documentation as available public information on websites. Identifying personal experience and opinion helps a researcher toward recognizing their own biases. To mitigate bias, I reviewed the transcripts, conducted bracketing, and engaged in reflective thinking to double-check for any instances for possible biases. I ensured that my personal experience did not bias the process while I collected and interpreted data. I ensured to prepare a complete list of my biases in advance in my reflective journal before conducting my interviews. The list included possible biases, such as researcher biases and participants biases. Member checking was another method I used to identify my own biases during data collection, interpretation, and results of this study. Member checking allows participants to take part in the research process by researchers giving participants the ability to fact check and authorize the researcher's interpretations of the data provided by the participants, which helps increase research credibility and validity (Iivari, 2018). During the interviews, I

interpreted their response and asked them through member checking if my interpretation was accurate, wherever I needed to clarify a participant's response.

Reliability and Validity

Research reliability and validity, along with the produced outcomes, play a crucial role in reflecting research quality (Hayashi et al., 2019). Reliability and validity are related to a qualitative study's trustworthiness, which is similarly a measure of the *credibility, dependability, confirmability,* and *transferability* of the data produced by a study to achieve homogenous and consistent results (Ghauri et al., 2020). In qualitative research, the foundation of reliability relies on the adequacy of data (Spiers et al., 2018).

Reliability

Yin (2018) defined reliability as the consistency and replicability of a case study's research methodology. Reliability in qualitative research means the extent to which consistency, replication, or repeatability in research can be achieved toward consistent findings (Bengtsson, 2016; Yin, 2018). Bengtsson (2016) found that data collection through the semi structured interview process, a researcher determines the reliability, which can be further enhanced with data comparisons, use of tabular analysis, constant comparisons, and comprehensive analysis for accuracy. Dependability in a case study is achieved from auditable documents that researchers use to enhance reliability for stability and consistency (Yin, 2018). I collected in-depth information and continued the interview until no new information was discovered. Marshall and Rossman (2016) found that a researcher could ensure rigor in a qualitative study through triangulation. I triangulated

the data through interview and supporting documents, such as digitalization project success stories, standard operating procedures for using digital tools, best practices for digitalizing supply chain operations as collected from participants. I made an effort in the data collection process to avoid errors in data classifications, coding, and any misinterpretation in my final analysis to establish the reliability.

Validity

Validity in qualitative research refers to measures, accuracy, and generalizability that truthfully and accurately describes the phenomena (Bengtsson, 2016). The process of validity increases the quality and integrity of the research finding (Amankwaa, 2016). Credibility refers to the truthfulness of the finding and, when presented with the context, are recognizable to people who share the experience (Stewart et al., 2017). I used a semistructured interview and documentary evidence as the two primary sources to support this qualitative case study. I transcribed the recorded interview using Otter, and the interview transcripts were shared with participants for their review on a zoom call to confirm the accuracy of the transcription. The participants were in agreement that no changes were needed. I used the original transcripts for my data analysis.

Credibility

The credibility (also known as internal validity) demonstrates and establishes the truth behind the findings (Amankwaa, 2016). Credibility in a qualitative study refers to the extent to which the data is an authentic representation of the subjects' experiences and the phenomenon under consideration. The credibility of a research study is maintained

when the researcher applies research methods that are scientifically qualified for qualitative research use (Bengtsson, 2016).

The member checking and triangulation processes can increase the credibility of results from a qualitative research study (Birt et al., 2016). Member checking allows participants to take part in the research process by researchers giving participants the ability to fact check and authorize the researcher's interpretations of the data provided by the participants, which helps increase research credibility and validity (Iivari, 2018). During the interviews, I interpreted their response and asked them through member checking if my interpretation was accurate, wherever I needed to clarify a participant's response. I transcribed the recorded interview using Otter, and the interview transcripts were shared with participants for their review on a zoom call to confirm the accuracy of the transcription. The participants were in agreement that no changes were needed. I used the original transcripts for my data analysis.

Transferability

Transferability (or external validity) refers to the extent to which the findings of a qualitative study can be applied to other setting and contexts, including professional practice and future research (Santiago-Delefosse et al., 2016). The transferability of a study requires a detailed and careful description of the study background, population sampling, and the finding of the study so that readers can determine the transferability of the research-based upon the findings (Bengtsson, 2016). I provided a detailed description of the background of the study, sampling methodology, the population size, eligibility

criteria for selecting the participants, and data analysis methodology so that other researchers may ascertain the transferability of my research.

Dependability

Dependability may be achieved if the study is repeatable with the same or an equivalent number of participants in the same context (Amankwaa, 2016). Zadvinskis et al. (2018) suggested that a qualitative study's dependability may be enhanced by establishing arduous sampling, member checking, using recommended and verifiable data collection and data analysis methods, and implementing other recommended procedures. I achieved dependability by recording the semistructured interviews with the participants using the audio recorder and then keeping careful coding notes throughout the data analysis process, which can then be checked against the audio recordings transcripts. Ensuring arbitrariness in the analysis and keeping the interpretation of the data to a minimum helped me achieving dependability.

Confirmability

Conformability or construct validity is the researcher's ability to keep records in an orderly manner of every single methodological choice they took throughout the research, such as data sources record, sampling decision, and informative system with execution (Amankwaa, 2016; Tong & Dew, 2016). I documented procedures, data collection, analysis, and interpretation methods in my reflective journal to enable myself to properly reflect on my methods and experiences in this study. Confirmability also helped provide signposts and benchmarks for future research conducted on my selected

topic.

Data Saturation

Data saturation represents the point during the data collection and data analysis processes at which further analysis no longer yields new codes or themes related to the phenomenon of interest (Yin, 2018). I collected input from identified participants until data saturation was achieved. I interviewed five supply chain business managers in the pharmaceutical industry that provided sufficient input to understand and postulate study results. During the interview, I asked clarifying questions until no new information was obtained from each participant. I reached data saturation when responses to questions failed to provide new information on codes, themes, and strategies.

Transition and Summary

Section 2 was a summary of the design and method for this multicase qualitative study. The objective of this qualitative multiple-case study is to explore the strategies used by some pharmaceutical managers to digitalize the integrated supply chain system to increase their profitability. The research study included collecting, analyzing, and interpreting the data to investigate and explore how pharmaceutical managers formulate and implement a strategy to digitalize the integrated supply chain system to increase efficiency, visibility, and profitability. The next section will include the presentations of the results and findings.

Section 3: Application to Professional Practice and Implications for Change

Introduction

The objective of this qualitative multiple case study was to explore the strategies used by pharmaceutical managers to digitalize the integrated supply chain system to increase their profitability. I used the TOC as the conceptual framework for reviewing organizational performances regarding efficiency, visibility, and profitability by digitalizing the integrated supply chain system. I conducted video conferencing interviews through Zoom with five individuals with SCM experience who have developed strategies to digitalize the integrated supply chain system. The three main themes resulting from the interviews and analyzing publicly available company documents were (a) constraints or barriers in current supply chain system, (b) digital technology enablers, and (c) sustainable, resilient, and agile supply chain systems.

Section 3 includes the presentation of the findings, applications for professional practice, and implications for social change. Additionally, in Section 3, I discuss recommendations for action and future research. I finish Section 3 by sharing my reflections and a conclusion.

Presentation of the Findings

The process I used to collect data for this study involved semistructured interviews with participants using Zoom and analyzing publicly available company documents to identify strategies pharmaceutical managers use to digitalize their integrated supply chain system to increase profitability. My participants were five senior

supply chain managers from four pharmaceutical companies in New Jersey who have successfully developed strategies to digitalize the integrated supply chain system to improve their business practices and profitability. Once I received consent from participants, I scheduled Zoom interviews with the participants. Before each interview began, I asked the participants for their consent to record the interviews using the Zoom application installed on my iPhone. Interviews lasted no more than 60 minutes. I followed the interview protocol (see Appendix A) when conducting each interview. In addition to the eight predetermined questions, I asked participants follow-up questions when necessary.

Following the interviews, I reiterated that I would transcribe the interviews and email each participant the interview transcripts and my interpretations of the interview transcripts for their review and approval. I concluded the interviews by thanking participants for their time and willingness to participate in this study. Upon completion of transcriptions, I provided participants with my interpretation of the interview transcripts as member checking process. I requested them to either respond to my email stating they approved or let me know if they disagreed with any of the information provided. The participants were also asked if they wanted to modify their answers. Each participant reviewed and approved the interpretations of the interview transcripts.

I used pseudonyms, such as P1 for participant 1, to name participant folders where I stored interview-related documents to protect the identities of participants. Once I received approval from each participant regarding interview transcripts, I entered each

five interview transcripts into ATLAS.ti so I could code and analyze data to identify themes that emerged from interviews. Each of the five participants reviewed the three themes I sent them in my transcript interpretation email and approved my interpretations of their responses to the interview questions.

Following the fifth interview, when no new information had been received from the participants or was forthcoming, I achieved data saturation and did not need to conduct additional interviews. I was able to relate the three themes to my research question: What strategies do pharmaceutical managers use to digitalize their integrated supply chain system to increase profitability? The five supply chain managers talked in detail about various factors that helped achieve desired supply chain state in term of attaining profitability for their organization. The three themes resulting from the interviews and analyzing publicly available company documents that contributed toward successful digital strategies used by supply chain managers to increase profitability were (a) constraints or barriers in the current supply chain system, (b) digital technology enablers, and (c) sustainable, resilient, and agile supply chain system. The analysis aligns with TOC, the conceptual framework for the study.

I performed the content analysis by using deductive coding and then identified three themes in ATLAS.ti. Using ATLAS.ti, I organized the collected data, maintained a list of codes, and identified themes. Table 2 shows the summary of codes, three themes that emerged from the interviews with five participants, and strategies used by the participants to address the problems in their earlier supply chain systems.

Table 2

Summary of Themes, Strategies, and Coding

Themes	Strategies	References coded for Theme
Constraints or barriers in the current supply chain system	Develop a deep understanding of all the constraints of the current supply chain. Develop a deep understanding and possibilities of the self-thinking supply chain. Define a vision for supply chain strategy aligned with the organization's overall strategy for digitalized operations. Develop a robust change management system by collaborating with internal and external stakeholders.	16
Digital technology enablers	Develop a business case by evaluating risk from specific digital enablers, digital system integrators, and application technologies in order. Prioritize those enablers and launch pilot projects to design solution, and then scale up by rolling out a full-scale digital model.	35
Sustainable, resilient, and agile supply chain system.	Establishing and measuring key performance indices (KPIs) to measure and improve supply chain effectiveness. Maintain sustainability and continue resilience during uncertain times.	11

I also used word cloud from ATLAS.ti for a visual representation to get the first look and summarize the interview transcripts. Word cloud allows the viewer to see the words that were used most frequently. The larger the size of a word in the cloud, the most frequently it was used. As shown in Figure 2, SAP, visibility, data, vision, cloud, integrity, regulatory, digitalization, SAP, agile, sustainability, analytics, and constraints were the most frequently used words by participants in the interview.

Figure 2

Most Frequent Words from Interviews

Theme 1: Identifying Constraints or Barriers in the Current Supply Chain System

The first theme that emerged during the interviews was the constraints or barriers in the current supply chain system. I was able to relate the theme to my research question as managers who understand the constraints or barriers of the current system can successfully implement the digital strategies and thus increase profitability. Planning and operational barriers in pharmaceutical industries by supply chain extension include difficulties in coordination between multiple stakeholders, quality control problems, difficulties for management of flows and lack in flexibilities, procurement and storage problems, logistics inefficiencies by low shelf life of medicines (Viegas et al., 2019). Cost and price barriers by presence of third-party logistics, counterfeiting, diversion of

medicines, and difficulties to monitor the supply chain by very basic nature of extension and diversity of items (Viegas et al., 2019). Compared to other industries, managers in a pharmaceutical industry suffer with many constraints, such as counterfeit issues, unfavorable reactions to the patients regarding efficacy, if temperature is not maintained during product life cycles, manufacturing and labeling issues, transportation and shipment issues, and storing and warehouse issues (Kapoor, 2018).

The five participants from four different pharmaceutical organizations mentioned the constraints or barriers they faced at the start of their digital implementations such as batch restrictions, good practice, quality guidelines, and regulations in countries of business, multiple stakeholders, and not having proper change management to interact with internal and external stakeholders. Other constraints were not having a smart automated system of records for end-to-end visibility, cold chain, missing digital maturity, and missing a cost-effective model in the supply chain. These constraints relate to the first theme of identifying constraints or barriers in the current supply chain system as per the TOC conceptual framework. P1 mentioned,

> I deal with the good practice, quality guidelines, and regulations from local authorities very often since we ship to several countries. We needed a system to effectively use of document management system and a system for effectively maintain quality data to show the authorities in case of adverse events. Data integrity is also one of the bigger needs in our industry. We must do things right at first time to meet goal of the end customers. Implementing change management

system including communication with our stakeholders is also one of the biggest constraints when we try to implement any solution in our supply chain system.

P2 mentioned,

> Our major issue was to not have system of records for end-to-end visibility in logistics, planning, scheduling, procurement, transportation, and financial. In Pharmaceutical industries we must establish an effective supply chain model to work with the constraints and system of record must help in dealing with supplier, regulatory bodies, and other multiple stake holders.

P3 mentioned,

> We supply our products globally everywhere and following food and drug administration regulation is must for our line of business. A system like global trade system was must for controlling supply chain issues at various point while dealing with customers and suppliers. In our logistic service providers, we use plenty of third-party systems and harmonizing their system in our system is a big challenge and one of the biggest barriers for any digital solution we implemented in past.

P4 mentioned,

> We needed to have digital maturity as we grown inorganically through acquisition. Outsourcing few of our manufacturing products to contract manufacturing organization, was also one of the biggest challenges as we did not have process to monitor the drugs produced by them throughout the supply chain

> cycle. We also adopted two parallel tracks, one for short team that we call them quick opportunities to improve existing system and then in long term improve system using incremental innovations. In long term we also have to go with digital disruptions by new players in market. In our biological plant, we had a capacity constraint and for that we had to find a new site or reconfigure existing.

P5 mentioned,

> The faster integration with cost effective model was our biggest challenge. We had a commitment with customer for arrival to their facilities to maintain potency and we need to have a system to monitor estimated time to destination. Meeting customer expectations is the biggest challenge in our industry in term of collaboration and communication. Sensing demand signal is one of the biggest constraints in our system as we have multiple stakeholders, such as manufacturing contractors, suppliers, third parties.

Related to the first theme of constraints, the word cloud from ATLAS.ti includes most frequently used words by participants in the interview as shown in Figure 3. Frequent word as used by participants are training, communication, change management, compliances, data integrity, regulatory, batch restrictions in different countries, demand sensing or forecasting, temperature sensitiveness, cold chain, third-party providers, restrictions, shelf life, expiry, auditable.

Figure 3

Most Frequent Words from Interviews Related to Theme 1

The following four primary strategies provides a detailed overview of the strategy used by the participants in first theme constraints or barriers in the current supply chain system. To address the problem of constraints or barriers as the initial theme, strategies are needed for managers to use to eliminate or minimize these problems.

Develop a Deep Understanding of all the Constraints of Current Supply Chain System

All five participants identified multiple constraints toward successfully implementing digital strategies in the pharmaceutical supply chain. P1 identified constraints such as data integrity, use of controlled process and certified documents, regulatory compliance from good practice, quality guidelines, regulations, and other local regulatory agencies, system lacking for tracking adverse events, and change management processes. P2 identified constraints such as multiple stakeholders, certifiable and auditable at highest level, regulatory compliance from good practice, quality guidelines, regulations, and other local regulatory agencies, cold chain processes, master data

integrity, system lacking for tracking the adverse events, change management processes. P3 identified constraints such as regulatory compliance from good practice, quality guidelines, regulations, and other local regulatory agencies, master data integrity, system lacking for tracking the adverse events, and change management processes. P4 identified constraints such as demand sensing, cost and pricing in different geographies, capacity and yield, and system lacking for tracking adverse events. P5 identified constraints such as systems lacking for tracking adverse events. P5 also identified regulatory compliance from good practice, quality guidelines, regulations, and other local regulatory agencies, restricted batches, temperature-sensitive, cold chain, third party logistics and multiple stakeholders, and cold chain.

Each participant discussed the importance of identifying all constraints and barriers related to their current supply chain system. The goal of each of the managers was to work toward a digital solution that recognizes the presence of these constraints and then look a solution that addresses and fits the purposes. Collaboration with vendors and business reengineering of their processes helped pharmaceutical managers deal with their present constraints efficiently.

Develop a Deep Understanding and Possibilities of Self-thinking Digital Supply Chain Integrated Ecosystem

Each of the participant identified the gap of not fully understanding the self-thinking supply chain integrated ecosystem when they started the digital supply chain initiatives. P1, P3, and P4 also shared the facts about not having relevant in-house

expertise. P2 and P5 suggested a need for a strategic alliance with external third parties to guide them to understand of digitalization possibilities in their existing supply chain system.

The self-thinking supply chain helps managers in continuously monitoring supply chain performances by analyzing massive volume of available data, forecast and identify risks, and then automatically act before the risk occurs (Calatayud et al., 2019). The self-thinking supply chain is driven by new digital technologies, designed to be self-aware, and require minimum human intervention to mitigate risk. The participants recommended exploring more understanding about the self-thinking supply chain for them to be able to make the accurate decisions in real-time, mitigate any risk from disruptions, and change in demand across the cycle. Understanding more about digital tools, such as IoT, AI, cloud, big data analytical tools that facilitate self-thinking supply chain will help organizations decide and get ready for digital transformations.

Define a Vision for Supply Chain Digital Strategy Aligned with the Organization's Overall Strategy for Digitalized Operations

The participants discussed the need for vision to implement supply chain digital strategy successfully. Everyone suggested that supply chain digital strategy should be either wholly aligned or part of a corporate strategy rather than completely detached from corporate strategy. An ideal scenario is when the digital strategy is a corporate vision and supply chain digitalization as part of that vision.

Senior leadership from non-information technology (IT) can adopt three strategies

to achieve digital transformation: create and procure endorsement for an IT-enabled business transformation vision, develop a robust non-IT business leadership team, and develop a change management function for the transformation (Eseryel, 2019). Senior leadership in a pharmaceutical company can include the strategies identified in this study while defining their digital vision and objectives.

Develop a Robust Change Management System by Collaborating with Internal and External Stakeholders

Each participant discussed the need for a robust change management system and identified it as the most fundamental need for any digital transformation. Effective communication and training throughout the life cycle of implementation played a crucial role in successful change management process, as suggested by the participants. P1, P4, and P5 highlighted the need of understanding self-thinking supply chain integrated ecosystem thoroughly before the start of the digital initiatives.

Employees of an organization must be trained while preparing for digital transformation (Mishra et al., 2019). The relationship between humans and technology will be effective only when it includes collaboration, interaction between teams, and training (Oyekan et al., 2017). Change management process as followed by participants just not included end users but also included external stakeholders, including vendors of digital tools and solutions. P1, P4, and P5 indicated that communication was the important factor, and supply chain digital initiative was very well received by end users of their organization. The training was a critical aspect, and participants emphasized the

need of multiple user training throughout the life cycle of digital transformation.

Findings Related to the Conceptual Framework

The findings from the interviews align with the TOC conceptual framework. Eliyahu Goldratt's (1990) TOC is a system-based management philosophy to understand and identify the constraints or barriers that limit a system from achieving higher performance. Implementation of digital strategy in pharmaceutical supply chain system is quite different than other industries as it needs to face various constraints, such as different audit and compliance regulation in the operating countries, cold chain temperature sensitiveness during transportation, manufacturing and labeling issues, shelf-life expiry, and cost and regulated price barrier in the country of operation. A constraint is defined as elements of the factor that limits the system from doing what it was designed to accomplish (Goldratt, 1990). These pose very different types of challenges to pharmaceutical managers. The business managers in pharmaceutical industries get encouraged by TOC to identify challenges associated with SCM strategies and find solutions to implement digital solutions successfully.

Findings Related to the Literature Review

The findings from the interviews also align with the pharmaceutical industry and pharmaceutical industry challenges sections found in my review of the professional and academic literature. Pharmaceutical manufacturing is performed in batches using control technologies and automation, which does not allow supply chain managers to make informed decisions (Sharma et al., 2020b). Pharmaceutical drug development is a long

process and after commercial drug launching, pharmaceutical managers face a different set of constraints and drivers as same set of supply chain systems need to take care of generics and biologics (Kapoor, 2018; Vincent, 2020). Demand forecasting in pharmaceuticals is also big constraint and results in Bullwhipeffects. Lack of the right information at the right time for the right decision-maker in the supply chain cycle is impact of the Bullwhip effect. Multiple stakeholders, including third-party logistics, also pose constraints for an effective supply chain. Maintaining temperature or cold chain during transportation toward maintaining efficacy is considered one of the biggest constraints in the effective supply chain in pharmaceutical industries.

Theme 2: Digital Technology Enablers

The second theme that emerged during the interviews was the digital technology enablers. I was able to relate the theme to my research question as managers who understand and work through digital technology enablers, and their implications can successfully implement the digital strategies and thus increase profitability. A digitalized organization is characterized by the use of digital enablers to carry out operational activities that may include purchase and sale of products and services, interactions with customers, collaboration with internal and external stakeholders, and execution of transactions within and outside the organization (Schwer et al., 2018). Supply chain is defined as a series of interconnected activities that involve the coordination, planning, and controlling of products and services between suppliers, manufacturers, and customers (Buyukozkan & Gocer, 2018). Digital technologies in the supply chain compared to

conventional technologies altered the way people in an organization collaborate with others compared to conventional supply chain consists of physical facilities scattered geographically with linear collaboration.

I have interviewed five participants from four different pharmaceutical organizations. They mentioned the digital enablers implemented to digitalize the supply chain in their organizations. Participants also discussed the criteria for overcoming the constraint toward selecting those digital tools and technologies. Cloud-based ERP systems, such as SAP was chosen by most of the participants as a system of record, a system of engagement, and a system of innovation. Cloud based SaaS system also fits into criteria for their system related needs. Data integrity was one of the critical criteria in pharmaceutical industry. The participants emphasized the need of big data analytical tools for end-to-end visibility in supply chain systems. These relate to the second theme of digital enablers. P1 mentioned,

> We wanted right for first time, and reduction in supply chain cycle. So, these were the two main criteria. To minimize any kind of adverse finding in order to ensure data integrity of our processes, as well whatever we do is right, first time. Also, for fully tracking and tracing every element in our content management lifecycle, right from the creation of the content to the I would say no archival or, or retirement of that content right from an occurrence of an event, whether it's internal within the good practice, quality guidelines, and regulations, or whether it is even an external adverse event reported by a customer. we can meet the end

> goal of the consumer, you know, which is basically providing them the best quality product at the right time. We have done in terms of digitizing is we have kind of introduced a global system that's commercially available out there in the market. And it's a cloud- based solution for, you know, our entire, our entire suite of quality management system, processes and flows, and so on, and so forth. And our good practice, quality guidelines, and regulations and content management. Everything has been moved to the cloud. We are also big on prototyping in all our sprints.

P2 mentioned,

> There are three systems that we primarily deal with. The first is system of record. So in this case, it is for SAP that we use. The next layer is what we call our systems of engagement, and systems of engagement are systems that are outside of our RP system, but are equally important from an organization standpoint. And those could be systems like our CRM systems, or our lane systems, or our ABS system. The system of engagement engages with system of record. And finally, on the last layer what we have done to enable supply chain practices to integrate all of the system of record, system of engagement, and system of innovation. By innovation, we mean implementing cloud, big data, artificial intelligence, blockchain, robotic process automation. Combining all of these three systems together, what we get is digital ecosystem. Our company's vision is also aligned with digitalization of digital ecosystem. the most important criteria in our supply

> chain system are integrated master data. So, your data backing up all of these transactions, your procurement transactions, your sales, transactions, financial, and your supply transaction, actually solid, when you talk about broken processes, they get broken because the data is broken, correct, and there isn't a continuous flow, or the data is different at the plant, we should be at the company level, we should be at the market level, because in pharma, you're dealing with these three entities.

P3 mentioned,

> We were scrambling to deploy a global system inside of supply chain as per digitalized vision from our organization. We were kind of defaulted to SAP as per agreement from the company, we separated. SAP is kind of the backbone and financial system, we use from a customer service point of view, right, we use service Cloud to maintain the basically everything about the customer from a contact center perspective, and, and all of those things related to sales field and, and customer service. We use Tableau right to really connect the customer data with the manufacturing data. As a core reporting system, that gets pushed out to the field. As I mentioned earlier, we use AERA to sit on top of SAP to provide insights and easily customized insights for our supply chain colleagues, both in the planning end as well as the execution and at the markets. Scalability is also important as the worst thing that can happen with a global organization is have one person or team doing well and leveraging tools and creativity to drive

business results.

P4 mentioned,

> When we talk about digitizing the supply chain or digital strategy, we're not Talking about technology. First, we're talking about business opportunity for us, right, that's kind of what problems are we trying to solve? What opportunities are we trying to trying to exploit? What strategies are we trying to support business strategies, then the technology roles and after, so we're talking about solutions. That's, that comes up. And almost afterwards when we do the people in process to rest. So but in this case, you know what, when we're talking about the incremental innovation, from a technology perspective, we're talking about using the technologies that we already have. So then extraction using from SAP using simplement. Using the AERA tools, that cognitive automation that's provided by Aera, it's using the azure, cloud and Power BI. So it's really about here we have a challenge or a problem or an opportunity to solve. to manufacture a biologic fast takes weeks, the yield difference between 90% and 91% is millions of dollars. So if we can, using the data that's available, through multivariate analysis, deliver a improve improvement in yield reduction cycle time, then it's a huge financial benefit. And that's one, that's one of the things that we're focusing on.

P5 mentioned,

> We implement that system tracking. Okay, so what this tracking does, I can give You some details, and then you can put in your research that this tracking is end

> to end model, it checks the end-to-end visibility from source to the destination, okay, so when we get the order from the source, and how we run MRP and get the demand signal, demanding that into the manufacturing plant, and then they produce, and then when it disappears from the manufacturing plant, and then it goes to the destination. We track every stage for our visibility, like it's an end to end visibility. our carriers like DHL or FedEx, they mentioned they have that temperature control track and they ship that product to the airport and then in the airport, everywhere we have a monitor sensor monitor to maintain the temperature to the drive and then it goes to the airport and then from the airport, it goes to the it goes to the destination flew through flight, but everywhere we maintain the temperature so that it goes to the customer without any interruption.

Related to the second theme of digital enablers, the word cloud from ATLAS.ti includes most frequently used words by participants in the interview as shown in Figure 4. Frequent word as used by participants are cloud, vision, sap, data, integration, analytics, metrics, KPI (key performance indices), quality, prototyping, piloting, yield, cost, integration.

Figure 4

Most Frequent Words from Interviews Related to Theme 2

The following two primary strategies provides a detailed overview of the strategy used by the participants in second theme digital technology enablers. To address the problem of digital technology enablers, strategies are needed for managers to use to eliminate or minimize these problems.

Develop a Business Case by Evaluating and Risk from Specific Digital Enablers, Digital System Integrators, and Application Technologies in Order

Each participant suggested a need a system of record, engagements, and innovation during their journey for supply chain digital transformation. The document generated by system must be certifiable and auditable at the highest level and must be accepted by regulatory bodies. SAP, which is an ERP software was an automatic choice for P1, P2, P3, P4, and P5. P2 further explained that SAP as a system of record helped

him in the digital supply chain functionality, such as logistics, planning, scheduling, procurement, manufacturing, transportation, billing, and financial. Tracking the adverse event is one of the most important parameters in any pharmaceutical industry. Each participant explained that the track and trace system built and customized in the SAP system helped the participants do business efficiently.

P1 suggested the use of cloud-based services and cloud-based SaaS (software as a service) systems for quality-related need supply chain digital journey. P1 further explained that LIMS system which is a cloud-based quality system helped him convert manual analog processes to digitally recorded systems is a must for good practice, quality guidelines, and regulations processes. P2 also suggested the use of HANA, which is cloud-based for managing their supply chain processes. P3 said about using service cloud to maintain everything from a customer center perspective.

Each participant strongly suggested the need for BDA. P2 said that analytics combined with AI, machine learning, and robotic process automation helped them immensely in the system of innovation. P2 has implemented most of the data analytics functionality from SAP. They have also implemented Qlikview, which provided them a data analytics platform on the SaaS model. P3 said about using SAP data analytics tools for their transactional needs for end-to-end visibility of processes. P3 also used tableau, and AERA data analytics tools for their supply chain need. P4 said that data analytics helped them in incremental innovation.

Each participant discussed the need for strong business case for steering

investment for supply chain digitalization. For ensuring a strong business case, these factors are critical to drive a strong business case: pursue a digital initiative that drives rapid business growth, leverage digital supply chain initiatives to support cost optimization, enhance supply chain agility through digitalization (Ramaswamy, 2021). P1, P3, and P5 suggested the need to work closely with senior management about digital initiatives by preparing a business case. P2 and P4 discussed the need for preparing metrics for benefit projection for digital initiatives and submit along with business cases.

Prioritize those Enablers and Launch Pilot Projects to Design Solutions, and then Scale up by Rolling out a Full-scale Digital Model

Each participant suggested prioritizing those digital enablers and then launching pilot projects on smaller scale. P1 said that they carry out digital projects in various sprints, and prototyping is a prerequisite for any sprint. P3 said that pilot decides if it is a green light to go or red light. P3 further told that in the case of large-scale deployment with major investment in technologies, piloting is just to work out the bugs and ensure that they have taken the right approach before they go live globally.

Findings Related to the Conceptual Framework

The findings from the interviews align with the TOC conceptual framework. TOC suggests working with the rest of the system once constraints are identified. A constraint prevents the system from achieving its goals, and there may not be hundreds or thousands of constraints in the supply chain system. An effective digital strategy around forecasting may help pharmaceutical organizations deal with internal constraints when the market

demands more than the organization can produce. Optimized demand sensing digital strategies may also help mitigate external constraints when the production is more than the market can accommodate. Forecast, source from vendor, manufacture, and delivery to end customers is not viewed as independent processes from TOC perspective. For achieving desired goals each of these areas must be aligned among themselves and must be integrated into overall digital supply chain strategies. Various strategies in theme helped supply chain managers to work with various constraints and then identify various digital enablers to work through those constraints.

Findings Related to the Literature Review

The findings from the interviews also align with the digital supply chain, the road map for digital supply chain strategies in pharmaceutical industry, and digital enablers sections found in my review of the professional and academic literature. Digital enablers from my literature review, such as IoT, ERP, cloud, machine learning, AI helped the business managers who were part of the study. Each organization used SAP which is one of the digital enablers as system of record, engagement, and innovation. The organizations widely used IoT during transportation and cold chain processes. Cloud computing also helped organizations in reducing costs, securing data, and improving the efficiencies of the overall supply chain system. As most of the managers of pharmaceutical organizations emphasized the importance of data integrity and sharing information among internal and external stakeholders, the cloud helped them in these aspects.

Theme 3: Sustainable, Resilience, and Agile Supply Chain System

The third theme that emerged from the interviews is continuing sustainable, resilience, and agile supply chain. I was able to relate the theme to my research question as managers who continue and keep improving with sustainability, resilient, and agility of the current system after successful implementation of digital strategies can increase profitability. The correlation between sustainability and the entire supply chain is well established, and the organizations require consideration and tracking (Marconi et al., 2017). Supply chain disruptions represent the most prominent risk in the pharmaceutical industry.

I interviewed five participants from four different pharmaceutical organizations. They mentioned the need for sustainable, agile, and resilient supply chain systems for continuous improvements in their supply chain systems. For the participants, resilience was a critical factor in a difficult situation like covid. Sustainability is equally important to maintain a green supply chain from environmental and social perspective. Each participant discussed the importance of maintaining KPIs and metrics to gauge the health of the current system. These relate to the third theme of sustainability, agile and resilient supply chain. Maintaining supply chain systems up and running by tapping full potential also matches with continuous improvement of my conceptual framework, TOC. P1 mentioned,

> We are working with agile way and delivering value to our customers. we are just reducing the cycle time using agile in our sprint, whether it's a video or whether

> it's a paper-based sop within the system, it is within seconds, it goes from creator of the workflow, of course, creation of the content could take as much time as it's needed. We are also generating a lot of metrics from our systems, and from our within, within our firewalls from our networks It help us to maintain health of our SaaS system.

P2 mentioned,

> In our implementations, we try to make key performance indices as performance indicator base. In each area, we have metrics and the baseline the metrics that say, in order to cash in supply chain, we look at what are the metrics like average customer wait time, logistics Response Time supply, material availability, DSO. After the rotation of the six months later, whether these metrics improved or not. So this one way of measuring the value out of implementation, which we've done. You also need to be resilient enough in order to innovate and get more products in your pipeline and acquire and diverse as business changes. The backbone of this is a good pitch to ecosystem.

P3 mentioned,

> The important I think, is to agree on harmonized key performance indices that are at some level in the organization, we can agree that these are critical criteria for success. The markets then ability to hit those criteria is at the end of the day, no matter what tool they're using. Are we hitting the criteria for success? Deployments are never perfect in first instance, but we also need to make sure

that we do not compromise on sustainability.

P4 mentioned,

> We oversell against forecast consistency; it doesn't mean we're doing well it means that we're not satisfying our customers. So there's one of the longer term digital disruption areas are looking at is cross functionally, how do we resolve our forecasting challenges to bring it to a place where we forecast with a reasonable percentage that we can deliver against and therefore keep customers happy, again, is a business focused. We measure metrics to keep ourselves in line with our baseline measurement and during uncertain time like covid, we do not fall back.

P5 mentioned,

> In the last six months, we had a big volume. Secondly, we had temperature restrictions, and we had to reach the destination on time. if you have to process these three things, then you'll need the disruption free system, proper tool, proper strategy and proper resources to make it happen. Sustainability and disruption free system is also needed to maintain the process effective in long term. We have a policy of reporting key metrics to the management to keep effectivity.

Related to the second theme of digital enablers, the word cloud from ATLAS.ti includes most frequently used words by participants in the interview as shown in Figure 5. Frequent word as used by participants are sustainability, yield, agile, efficient, resilient, disruption, accuracy, maturity, and capacity.

Figure 5

Most Frequent Words from Interviews Related to Theme 3

The following two strategies provides a detailed overview of the strategies used by the participants in the third theme sustainability, resilience, and agile supply chain system. To address the problem of sustainability, resilience, and agile supply chain system as the initial theme, strategies are needed for managers to use to eliminate or minimize these problems.

Establishing and Measuring Key Performance Indices (KPI) to Measure and Improve Supply Chain Effectiveness

Each participant discussed the need of building key performance indices (KPI) to measure the effectiveness of the digital solution during the implementation and post the implementations. Documents provided by them also proved that KPIs were the primary strategies of plan for digital milestones and business process improvements. P1 said they are generating plenty of metrics from their current digitalized system, and that is helping them to monitor the current state of their system. P2 said they are generating 50 to 60

metrics across the processes to measure the effectiveness of the system whether they ended up with a better digital ecosystem or not. P3 said about generating key performance indices using analytics to keep a check in the current system. P3 further said about generating harmonized key performance indices at some level in organization with an agreement with everyone to be able to meet criteria, which is a necessary for success. P4 said key performance indices are necessary for measuring the success of digital maturity. P5 implemented key performance indices in critical areas, such as transportation, working with logistics partners, and measuring the efficacy of pharmaceutical drugs.

Maintain Sustainability and Continue Resiliency to Prepare for Uncertain Time

Each participant discussed the need to create a sustainable system. They emphasized the necessity to maintain resiliency during an uncertain time, such as Covid. Managers must adopt a self-thinking system approach and focus on processes and measures to build an organization that is sustainable, reliable, and resilient (Gossett et al., 2019).

Findings Related to the Conceptual Framework

The findings from the interviews align with theTOC conceptual framework. Managers using TOC frameworks can either subordinate and synchronize or elevate the performance of the constraints to improve the performance of the supply chain. Pharmaceutical supply chain managers may take help of KPIs gauge performance using quantitative metrics, and subsequently, any action they need to take using TOC

framework. TOC framework suggests going to step one of identifying the constraints if new constraints are surfaced or constraints are shifted. During the covid pandemic, a new constraint of disruption occurred because of capacity constraints and maintaining very low temperatures during transportation at a remote location around the world. As suggested by TOC, the supply chain managers in pharmaceutical companies need to work toward formulating a new digital strategy or modifying the existing strategies to mitigate the newfound constraints.

Findings Related to the Literature Review

The findings from the interviews also align with the disruption and agility in the digital supply chain and sustainability in the digital supply chain sections found in my professional and academic literature. The covid situation has made this even more pressing concern for each of the business managers. In a pharmaceutical global chain network, entities may be located and moved through different geographical locations globally, and each transportation link may witness disruptions. The situation is even more evident after the covid situation when transporting active ingredients raw materials from remote vendors to manufacturing and packaging sites is far more challenging than before and leading to the disruptions of the entire supply chain network. Resiliency in the supply chain network may help a pharmaceutical organization bounce back to a new stable condition level even after any major disruption risk. The pharmaceutical organization must plan for an alternative and back up raw material supplier selection with the aim of mitigating disruption risk by reducing transportation cost with less lead time and enhance

quality.

Applications to Professional Practice

In this study, I explored the strategies that pharmaceutical supply chain managers used to digitalize their integrated supply chain system to increase profitability. The eligibility criteria for selecting the participants for this multiple-case study includes five business managers who have successfully implemented digital supply chain strategies in their organizations. The three themes that emerged from data collection were (a) constraints or barriers in current supply chain system, (b) digital technology enablers, (c) sustainable, resilient, and agile supply chain. In this study, participants discussed how establishing successful digital supply chain strategies could increase profitability.

The results of this study could help business leaders who operates in silos by maintaining the broken non-digitalized disconnected linear system by digitalizing their integrated supply chain systems. The result of this study could also help business leaders understand that cost- effectiveness is an important parameter to maintain supply chain efficiency and improve bottom line of the company. Professional practice leaders might use these three themes to understand the strategies pharmaceutical managers used to digitalize their integrated supply chain system to increase profitability.

Implications for Social Change

The results of this study can positively impact social change by helping supply chain managers understand the primary strategies needed to digitalize integrated supply chain systems. Improving the supply chain system in pharmaceutical industries may help

improve the quality-of-care patients receive by potentially reducing healthcare costs resulting from decreased costs, which could benefit community by providing community members with more affordable, higher quality, and reliable healthcare services that can augment an individual's self-worth and dignity. Managers at pharmaceutical companies could pass the cost savings to community members by providing patients with more affordable medical services.

Monitoring counterfeit products and protecting consumers from adverse effects are critical elements in a pharmaceutical industry. An effective supply chain strategy in a pharmaceutical company must ensure that end consumers are protected. The green supply chain is also important to protect stakeholders and the environment, and integrated digital supply chain process helps organizations maintain this. The results of this study may contribute to positive social change by leading to lower prices for end consumers and improving the experience of patients who receive their medication supplies from pharmaceutical companies.

Recommendations for Action

In the study, I explored the strategies that pharmaceutical managers used to digitalize their integrated supply chain system. The three themes that emerged included constraints or barriers toward implementing digital strategies in pharmaceutical industries, criteria for selecting digital strategies and type of digital tools implemented, and continuing to keep improving with resilient, sustainable, and agile supply chain. The result indicated that the pharmaceutical supply chain managers could follow the vision of

their organization toward the implementation of digital solutions, while paying close attention to the strategies as explored in this study.

Other stakeholders in the pharmaceutical industries who could benefit from the study include pharmaceutical senior organizational leadership and other stakeholders such as supply chain digital automation vendors. Senior leadership may define their organizational digital vision as aligned to the strategies as defined in the study. Vendors for supply chain digital automation can also build mutual benefitting solutions which fit the demand and requirements from end users of pharmaceutical companies.

Once the findings of this study are published, I can disseminate results to supply chain managers in New Jersey who are seeking to improve effectivity of supply chain processes. The results can be discussed during continuing education conferences for leaders, and organizational meetings held by pharmaceutical management. The finding of this research could also provide valuable insights to future researchers interested in further study of supply chain digital solutions in pharmaceutical companies. Also, the results could be dispersed in scholarly supply chain journals.

Recommendations for Future Research

The purpose of this qualitative multiple-case study is to explore the strategies used by some pharmaceutical managers to digitalize the integrated supply chain system to increase their profitability. In this study, I interviewed five senior supply chain managers from four pharmaceutical companies in New Jersey who have successfully developed strategies to digitalize the integrated supply chain system to improve their business

practices and profitability. Since my sample size included five participants who work at four companies in New Jersey, a recommendation for future research is to use an appropriate number of managers who work globally in various regions of the different countries or multiple regions of the United States. This study focused on qualitative research, so future research may apply quantitative research to compile and analyze data regarding digital strategies. The critical variable in quantitative research may include supply chain integration, collaboration, digital enablers, and adaptability that may help successful digitalization strategies in pharmaceutical industries. Perhaps quantitative research will allow researchers to reach a large population. Because of ever- increasing contemporary technologies in other industries, more pharmaceutical companies are building their vision for digitalizing by incorporating more tools and technologies.

Reflections

The journey to accomplishing doctorate in business administration seemed a daunting task in starting, and I needed to push my intellectual ability to reach the finishing end. Fortunately, I did not face any challenges to select and interviewing the participants. They took pride and shared the success story of their digital journey as part of the interview process. As part of a qualitative research course, I conducted a small project, and I was able to use the learning from that pilot effectively.

I work as a supply chain leader in a global pharmaceutical company and have extensive experience in supply chain digitalization strategies. I was involved in various digital initiatives that my leadership decided to implement to digitally transform my

company's supply chain processes. Understanding and mitigating my personal bias was critical for this study as I have preconceived ideas and assumptions regarding digitalization strategies in an organization. Despite my work experience, I abided by Walden University's standards to ensure I did not incorporate personal bias in my research process. I ensured to prepare a complete list of my personal biases in advance before conducting my interview. The list included all possible biases, such as researcher biases and participants biases.

Conclusion

The purpose of this qualitative multiple-case study was to explore the strategies used by some pharmaceutical managers to digitalize the integrated supply chain system to increase their profitability. The supply chain in pharmaceutical industry plays an important role to keep and enhancing the health of society which reveals the importance and distinction of this chain compared to chains from other industries (Mahani et al., 2018). Business leaders who use emerging digital enablers like the IoT, AI, cloud computing, and BDA for business advantages, could enhance business performance with improved financial performance and added value (Witkowski, 2017). The managers in an organization with high digital operations by implementing digital supply chain strategies can expect 4.1% annual efficiency gains while boosting revenue by 2.9% per year (Buyukozkan & Gocer, 2018). The business managers from a non-digital organization suffer from a complex business process resulting in fragmented labor-intensive and frustrated customer experiences and are often made worse by the product silos within

their company (Weill & Woerner, 2018).

The supply chain digital transformation is about establishing a vision for how digital strategies and applications can improve service, cost, quality, agility, inventory levels, and consistently improving organizational changes and processes that use these digital technologies to drive operational excellence (Alice et al., 2020). Internalization of digitalization and incorporate in the vision and operational methodologies to leverage maximum benefits by selecting the best suitable technological solutions (Buyukozkan & Gocer, 2018). The chosen conceptual framework for this study was the TOC. I used Eliyahu Goldratt's (1990) TOC to understand and identify the constraints that limit a system from achieving higher performance. With the help of the TOC conceptual framework, I explored the strategies, digital tools and technologies, the participating pharmaceutical managers digitalized their integrated supply chain system successfully.

I identified three themes in this study. The themes were (a) constraints or barriers toward implementing digital strategies in pharmaceutical industries, (b) criteria for selecting digital strategies and type of digital tools implemented, and (c) continuing to keep improving with the resilient, sustainable, and agile supply chain. The identified themes align with the conceptual framework and review of professional and academic literature. The findings of this study can positively influence social change by Improving the supply chain system in pharmaceutical industries may help improve the quality-of-care patients receive by potentially reducing healthcare costs resulting from decreased costs, which could benefit community by providing community members with more

affordable, higher quality, and reliable healthcare services that an augment an individual's self-worth and dignity. The findings could positively influence pharmaceutical supply chain managers in general by providing them with important strategies. With diligent planning and execution, the supply chain digitalization initiative can be successful, sustainable, and resilient.

References

Agrawal, P. (2018). Artificial intelligence in drug discovery and development. *Journal of Pharmacovigilance*, *06*(02). https://doi.org/10.4172/2329-6887.1000e173

Agrawal, P., & Narain, R. (2018). Digital supply chain management: An overview. *IOP Conference Series: Materials Science and Engineering*, *455*, 196–202. https://doi.org/10.1088/1757-899X/455/1/012074

Akhtar, P., Khan, Z., Tarba, S., & Jayawickrama, U. (2018). The internet of things, dynamic data and information processing capabilities and operational agility. *Technological Forecasting and Social Change*, *136*, 307–316. https://doi.org/10.1016/j.techfore.2017.04.023

Albarghouthi, M., Qi, B., Wang, C., & Abbad, M. (2020). ERP adoption and acceptance in Saudi Arabia higher education: A conceptual model development. *International Journal of Emerging Technologies in Learning*, *15*(15), 110–112. https://doi.org/10.3991/ijet.v15i15.12039

Alice, K., Racher, J., & Seyfert, A. (2020). Supply Chain 4.0- The next generation digital supply chain. https://www.supplychaindigital.com/technology-4/mckinsey-and-company-next-generation-digital-supply-chain

Alzaman, C., Zhang, Z.-H., & Diabat, A. (2018). Supply chain network design with direct and indirect production costs: Hybrid gradient and local search based heuristics. *International Journal of Production Economics*, *203*, 203–215. https://doi.org/10.1016/j.ijpe.2018.06.004

Amankwaa, L. (2016). Creating protocols for trustworthiness in qualitative research. *Journal of Cultural Diversity, 23*(3), 121–127. https://pubmed.ncbi.nlm.nih.gov/29694754/

Ames, H., Glenton, C., & Lewin, S. (2019). Purposive sampling in a qualitative evidence synthesis: A worked example from a synthesis on parental perceptions of vaccination communication. *BMC Medical Research Methodology*, *19*(1), 26. https://doi.org/10.1186/s12874-019-0665-4

Andrade, H. L. (2019). A critical review of research on student self-assessment. *Frontiers in Education, 4*(87). https://doi.org/10.3389/feduc.2019.00087

Ashby, A. (2018). Developing closed loop supply chains for environmental sustainability: Insights from a UK clothing case study. *Journal of Manufacturing Technology Management, 29*(4), 699–722. https://doi.org/10.1108/JMTM-12-2016-0175

Asl-Najafi, J., & Yaghoubi, S. (2021). A novel perspective on closed-loop supply chain coordination: Product life-cycle approach. *Journal of Cleaner Production*, *289*, Article 125697. https://doi.org/10.1016/j.jclepro.2020.125697

Attaran, M. (2017). The internet of things: Opportunities for business and society. *Journal of Strategic Innovation and Sustainability, 12*(1), 10–29. http://www.na-businesspress.com/JSIS/JSIS12-1/AttaranM_abstract.html

Atzori, L., Iera, A., & Morabito, G. (2017). Understanding the internet of things: Definition, potentials, and societal role of a fast-evolving paradigm. *Ad Hoc*

Networks, *56*, 122–140. https://doi.org/10.1016/j.adhoc.2016.12.004

Azghandi, R., Griffin, J., & Jalali, M. S. (2018). Minimization of drug shortages in pharmaceutical supply chains: A simulation-based analysis of drug recall patterns and inventory policies. *Complexity*, *2018*, 1–14. https://doi.org/10.1155/2018/6348413

Behner, P., & Ehrhardt, M. (2016). Digitization in pharma: Gaining an edge in operations. https://www.strategyand.pwc.com/gx/en/insights/2016/digitization-in-pharma/digitization-in-pharma.pdf

Bel, R. (2018). A property rights theory of competitive advantage. *Strategic Management Journal, 39*(6), 1678–1703. https://doi.org/10.1002/smj.2707

Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. *Nursing Plus Open*, *2*, 8–14. https://doi.org/10.1016/j.npls.2016.01.001

Bernard, H. R. (2013). *Social research methods: Qualitative and quantitative approaches* (2nd ed.). Sage.

Betcheva, L., Erhun, F., & Jiang, H. (2021). Om forum: Supply chain thinking in healthcare: Lessons and outlooks. *Manufacturing & Service Operations Management, 23*(6), 1333–1353. https://doi.org/10.1287/msom.2020.0920

Birt, L., Scott, S., Cavers, D., Campbell, C., & Walter, F. (2016). Member checking: A tool to enhance trustworthiness or merely a nod to validation? *Qualitative Health Research*, *26*(13), 1802–1811. https://doi.org/10.1177/1049732316654870

Blackwood, R. A., Maio, R. F., Mrdjenovich, A. J., VandenBosch, T. M., Gordon, P. S.,

Shipman, E. L., & Hamilton, T. A. (2015). Analysis of the nature of IRB contingencies required for informed consent document approval. *Accountability in Research*, *22*(4), 237–245. https://doi.org/10.1080/08989621.2014.956866

Borangiu, T., Trentesaux, D., Thomas, A., Leitão, P., & Barata, J. (2019). Digital transformation of manufacturing through cloud services and resource virtualization. *Computers in Industry*, *108*, 150–162. https://doi.org/10.1016/j.compind.2019.01.006

Bouwman, H., Nikou, S., Molina-Castillo, F. J., & de Reuver, M. (2018). The impact of digitalization on business models. *Digital Policy, Regulation and Governance*, *20*(2), 105–124. https://doi.org/10.1108/DPRG-07-2017-0039

Bromley, E., Mikesell, L., Jones, F., & Khodyakov, D. (2015). From subject to participant: Ethics and the evolving role of community in health research. *American Journal of Public Health*, *105*(5), 900–908. https://doi.org/10.2105/AJPH.2014.302403

Busse, C., Kach, A. P., & Wagner, S. M. (2017). Boundary conditions: What they are, how to explore them, why we need them, and when to consider them. *Organizational Research Methods*, *20*(4), 574–609. https://doi.org/10.1177/1094428116641191

Buyukozkan, G., & Gocer, F. (2018). Digital supply chain: Literature review and a proposed framework for future research. *Computers in Industry, 97* (5), 157–177. https://doi.org/10.1016/j.compind.2018.02.010

Calatayud, A., Mangan, J., & Christopher, M. (2019). The self-thinking supply chain. *Supply Chain Management: An International Journal*, *24*(1), 22–38. https://doi.org/10.1108/SCM-03-2018-0136

Cao, Q., Schniederjans, D. G., & Schniederjans, M. (2017). Establishing the use of cloud computing in supply chain management. *Operations Management Research*, *10*(2), 47–63. https://doi.org/10.1007/s12063-017-0123-6

Chang, J., Liao, H., & Zhang, Z. (2019). Third-party cold chain medicine logistic Provider selection by a rough set-based gained and lost dominance score method. *2019 IEEE Symposium Series on Computational Intelligence (SSCI)*, 3287–3292. https://doi.org/10.1109/SSCI44817.2019.9003103

Clifton, J. (2021). What does contract manufacturing looks like in Pharma? https://ispe.org/pharmaceutical-engineering/ispeak/future-contract-manufacturing-pharmaceutical-industry

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry & research design: Choosing among five approaches* (4th ed.). Sage

Croom, S., Vidal, N., Spetic, W., Marshall, D., & McCarthy, L. (2018). Impact of social sustainability orientation and supply chain practices on operational performance. *International Journal of Operations & Production Management*, *38*(12), 2344–2366. https://doi.org/10.1108/IJOPM-03-2017-0180

Cypress, B. (2018). Qualitative research methods: A phenomenological focus. *Dimensions of Critical Care Nursing*, *37*(6), 302–309.

https://doi.org/10.1097/DCC.0000000000000322

Daher, M., Carre, D., Jaramillo, A., Olivares, H., & Tomicic, A. (2017). Experience and meaning in qualitative research: A conceptual review and a methodological device proposal. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research, 18*(3). https://www.qualitative-research.net/index.php/fqs/article/view/2696/4130

Dalal, R., & Akdere, M. (2018). Talent development: Status quo and future directions. *Industrial and Commercial Training, 50*, 342–355. https://doi.org/10.1108/ICT-03-2018-0033

Dash, R., McMurtrey, M., Rebman, C., & Kar, U. (2019). Application of artificial intelligence in automation of supply chain management. *Journal of Strategic Innovation and Sustainability*, *14*(3). https://doi.org/10.33423/jsis.v14i3.2105

Dikko, M. (2016). Establishing construct validity and reliability: Pilot testing of a qualitative interview for research in Takaful. *Qualitative Report, 21* (3), 521-528. https://nsuworks.nova.edu/tqr/vol21/iss3/6

Ding, B. (2018). Pharma Industry 4.0: Literature review and research opportunities in sustainable pharmaceutical supply chains. *Process Safety and Environmental Protection*, *119*, 115–130. https://doi.org/10.1016/j.psep.2018.06.031

Donzanti, B. A. (2018). Pharmacovigilance is everyone's concern: Let's work it out together. *Clinical Therapeutics*, *40*(12), 1967–1972. https://doi.org/10.1016/j.clinthera.2018.09.016

Ehie, I., & Ferreira, L. M. D. F. (2019). Conceptual development of supply chain digitalization framework. *IFAC-PapersOnLine*, *52*(13), 2338–2342. https://doi.org/10.1016/j.ifacol.2019.11.555

El Baz, J., & Laguir, I. (2017). Third-party logistics providers (Tpls) and environmental sustainability practices in developing countries: The case of Morocco. *International Journal of Operations & Production Management*, *37*(10), 1451. https://doi.org/10.1108/IJOPM-07-2015-0405

Eltawy, N., & Gallear, D. (2017). Leanness and agility: A comparative theoretical view. *Industrial Management & Data Systems*, *117*(1), 149–165. https://doi.org/10.1108/IMDS-01-2016-0032

Ennever, F. K., Nabi, S., Bass, P. A., Huang, L. O., & Fogler, E. C. (2019). Developing language to communicate privacy and confidentiality protections to potential clinical trial subjects: Meshing requirements under six applicable regulations, laws, guidelines and funding policies. *Journal of Research Administration, 50*(1), 20–44. https://www.strainternational.org/resources/journal

Eseryel, U. Y. (2019). The case of "Med-Global": IT-enabled innovation and implementation by non-IT business unit leaders. *Strategy & Leadership*, *47*(2), 43–48. https://doi.org/10.1108/SL-01-2019-0013

Fatorachian, H., & Kazemi, H. (2021). Impact of industry 4.0 on supply chain performance. *Production Planning & Control*, *32*(1), 63–81. https://doi.org/10.1080/09537287.2020.1712487

Fusch, P., Fusch, G. E., & Ness, L. R. (2018). Denzin's paradigm shift: Revisiting triangulation in qualitative research. *Journal of Social Change*, *10*(1). https://doi.org/10.5590/JOSC.2018.10.1.02

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

Giannakis, M., Spanaki, K., & Dubey, R. (2019). A cloud-based supply chain management system: Effects on supply chain responsiveness. *Journal of Enterprise Information Management*, *32*(4), 585–607. https://doi.org/10.1108/JEIM-05-2018-0106

Gobble, M. M. (2018). Digitalization, digitization, and innovation. *Research-Technology Management*, *61*(4), 56–59. https://doi.org/10.1080/08956308.2018.1471280

Goldratt, E. M. (1990). *Theory of constraints*. North River.

Gong, C., & Ribiere, V. (2020). Developing a unified definition of digital transformation. *Technovation*, 102217. https://doi.org/10.1016/j.technovation.2020.102217

Gossett, K. D., Padgett, J. D., Pierce, S. M., & Scott, J. L. (2019). Complex adaptive system theory and the TAU conceptual framework for understanding healthcare and human services in the United States. *Journal of academic perspectives, 2019* (2), 1-28. https://www.journalofacademicperspectives.com/back-issues/volume-019/volume-2019-no-2/

Gouda, S. K., & Saranga, H. (2018). Sustainable supply chains for supply chain sustainability: Impact of sustainability efforts on supply chain risk. *International*

Journal of Production Research, *56*(17), 5820–5835. https://doi.org/10.1080/00207543.2018.1456695

Green, K. W., Inman, R. A., Sower, V. E., & Zelbst, P. J. (2019). Impact of JIT, TQM and green supply chain practices on environmental sustainability. *Journal of Manufacturing Technology Management*, *30*(1), 26–47. https://doi.org/10.1108/JMTM-01-2018-0015

Greener, S. (2018). Research limitations: The need for honesty and common sense. *Interactive Learning Environments*, *26*(5), 567–568. https://doi.org/10.1080/10494820.2018.1486785

Grover, V., Chiang, R. H. L., Liang, T.-P., & Zhang, D. (2018). Creating strategic business value from big data analytics: A research framework. *Journal of Management Information Systems*, *35*(2), 388–423. https://doi.org/10.1080/07421222.2018.1451951

Gunasekaran, A., Papadopoulos, T., Dubey, R., Wamba, S. F., Childe, S. J., Hazen, B., & Akter, S. (2017). Big data and predictive analytics for supply chain and organizational performance. *Journal of Business Research*, *70*, 308–317. https://doi.org/10.1016/j.jbusres.2016.08.004

Gupta, S., Drave, V. A., Bag, S., & Luo, Z. (2019). Leveraging smart supply chain and information system agility for supply chain flexibility. *Information Systems Frontiers*, *21*(3), 547–564. https://doi.org/10.1007/s10796-019-09901-5

Haddud, A., DeSouza, A., Khare, A., & Lee, H. (2017). Examining potential benefits and

challenges associated with the internet of things integration in supply chains. *Journal of Manufacturing Technology Management*, *28*(8), 1055–1085. https://doi.org/10.1108/JMTM-05-2017-0094

Hasanat, R. T., Arifur, R., Mansoor, N., Mohammed, N., Rahman, M. S., & Rasheduzzaman, M. (2020). An IOT based real-time data-centric monitoring system for vaccine cold chain. *2020 IEEE East-West Design & Test Symposium,* 1–5. https://doi.org/10.1109/EWDTS50664.2020.9225047

Hayashi, J. P., Abib, G., & Hoppen, N. (2019). Validity in qualitative research: A processual approach. *The Qualitative Report, 24*(1), 98-112. https://nsuworks.nova.edu/tqr/

Holloway, I., & Galvin, K. (2017). *Qualitative research in nursing and healthcare* (4th edition). John Wiley & Sons Inc.

House, J. (2018). Authentic vs elicited data and qualitative vs quantitative research methods in pragmatics: Overcoming two non-fruitful dichotomies. *System*, *75*, 4–12. https://doi.org/10.1016/j.system.2018.03.014

Hsiao, Y., & Chen, C. (2013). Branding vs contract manufacturing: Capability, strategy, and performance. *Journal of Business & Industrial Marketing*, *28*(4), 317–334. https://doi.org/10.1108/08858621311313910

Iddris, F. (2018). Digital supply chain: Survey of the literature. *International Journal of Business Research and Management, 9(1) 47–61*. https://www.cscjournals.org/library/manuscriptinfo.php?mc=IJBRM-257

Iivari, N. (2018). Using member checking in interpretive research practice: A hermeneutic analysis of informants' interpretation of their organizational realities. *Information Technology & People, 31*(1), 111-133. https://doi.org/10.1108/ITP 07-2016-0168

Jacques, A. (2017). The digital supply chain: Seizing pharma's untapped opportunity. *Pharmaceutical Technology, 41* (2), s20–s23. https://www.pharmtech.com/view/digital-supply-chain-seizing-pharma-s-untapped-opportunity

James, N. (2017). Supply chain digitalization: Delivering sustainable cross-functional change. *Journal of Business Forecasting, 36*(4), 36–39. https://ibf.org/knowledge/jbf-articles/supply-chain-digitalization-delivering-sustainable-cross-functional-change-1164

Kamalahmadi, M., & Parast, M. M. (2017). An assessment of supply chain disruption mitigation strategies. *International Journal of Production Economics*, *184*, 210–230. https://doi.org/10.1016/j.ijpe.2016.12.011

Kane, G., Palmer, D., Phillips, A. N., & Kirron, D. (2015). Is your business ready for a digital future? *MIT Sloan Management review, 56* (4), 21–25. https://sloanreview.mit.edu/article/is-your-business-ready-for-a-digital-future/

Kapoor, D. (2018). An overview on pharmaceutical supply chain: A next step toward good manufacturing practice. *Drug Designing & Intellectual Properties International Journal*, *1*(2). https://doi.org/10.32474/DDIPIJ.2018.01.000107

Kim, J., & Jeong, J. (2019). Design and performance analysis of an industrial iot-based mobility management for smart manufacturing. *2019 IEEE 10th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON)*, 0471–0476. https://doi.org/10.1109/IEMCON.2019.8936162

Klett, D. (2020). Smarter supply chain through AI *foresight: The International Journal of Applied Forecasting*, 56(08), 30–35. https://econpapers.repec.org/article/forijafaa/y_3a2020_3ai_3a56_3ap_3a30-35.htm

Klumpp, M. (2018). Automation and artificial intelligence in business logistics systems: Human reactions and collaboration requirements. *International Journal of Logistics Research and Applications*, *21*(3), 224–242. https://doi.org/10.1080/13675567.2017.1384451

Korpela, K., Hallikas, J., & Dahalberg, T. (2017). Digital supply chain transformation toward blockchain integration, Proceedings of the 50th Hawaii International Conference on system science, Waikoloa, HI, January, pp. 4182–419. https://www.semanticscholar.org/paper/Digital-Supply-Chain-Transformation-toward-Korpela-Hallikas/6ff218ab03660c71e15b3225ee7a501c0fa5beb6

Kovács, G., & Falagara, S. I. (2021). Lessons learned from humanitarian logistics to manage supply chain disruptions. *Journal of Supply Chain Management*, *57*(1), 41–49. https://doi.org/10.1111/jscm.12253

Kudláč, Š., Štefancová, V., & Majerčák, J. (2017). Using the saaty method and the fmea

method for evaluation of constraints in logistics chain. *Procedia Engineering*, *187*, 749–755. https://doi.org/10.1016/j.proeng.2017.04.433

Kumar, A., & Kushwaha, G. S. (2018). Supply chain management practices and operational performance of fair prices shops in India: An empirical study. *Logforum*, *14*(1), 85–99. https://doi.org/10.17270/J.LOG.2018.237

Kuruvilla, S. J. (2017). Theory of constraints and thinking process. *International Journal of Business Insight & Transformation, 11*, 10–14. http://eds.a.ebscohost.com/eds/pdfviewer/pdfviewer?vid=1&sid=59e33ee8-0b7e-4767-8641-8b6dea0aea45%40sessionmgr4006

Kusiak, A. (2018). Smart manufacturing. *International Journal of Production Research*, *56*(1–2), 508–517. https://doi.org/10.1080/00207543.2017.1351644

Lakdawalla, D. N. (2018). Economics of the pharmaceutical industry. *Journal of Economic Literature*, *56*(2), 397–449. https://doi.org/10.1257/jel.20161327

Lasch, R. (2018). Supply chain disruption models: A critical review (5th edition). *Bundesvereinigung Logistik*. https://doi.org/10.23773/2018_5

Laurin, F., & Fantazy, K. (2017). Sustainable supply chain management: A case study at *Transnational Corporations Review*, *9*(4), 309–318. https://doi.org/10.1080/19186444.2017.1401208

Lee, Y. Y., & Falahat, M. (2019). The impact of digitalization and resources on gaining competitive advantage in international markets: Mediating role of marketing, innovation and learning capabilities. *Technology Innovation Management Review*,

9(11), 26–38. https://doi.org/10.22215/timreview/1281

Lehmann, S. (2018). Operational excellence index- part 2: The digital transformation. *Hydocarbon Processing*, *3,* 27–28. https://www.hydrocarbonprocessing.com/magazine/2018/march-2018/columns/digital-operational-excellence-index-part-2-the-digital-transformation

Li, F. (2020). The digital transformation of business models in the creative industries: A holistic framework and emerging trends. *Technovation*, *92–93*, 102012. https://doi.org/10.1016/j.technovation.2017.12.004

Liao, S.-H., Hu, D.-C., & Ding, L.-W. (2017). Assessing the influence of supply chain collaboration value innovation, supply chain capability and competitive advantage in Taiwan's networking communication industry. *International Journal of Production Economics*, *191*, 143–153. https://doi.org/10.1016/j.ijpe.2017.06.001

Liu, G., Aroean, L., & Ko, W. W. (2019). A business ecosystem perspective of supply chain justice practices: A study of a marina resort supply chain ecosystem in Indonesia. *International Journal of Operations & Production Management*, *39*(9/10), 1122–1143. https://doi.org/10.1007/s12008-019-00548-9

Mahani, F. S., Yaghoubi, S., Motlagh, H. S., & Nematollahi, M. (2018). Order quantity optimization in a two-level pharmaceutical supply chain organization. *Journal of Industrial and System Engineering. 11* (1)*,* 127–143. *http://www.jise.ir/article_49111_6cc51491585c3bfc0e5084172b744cef.pdf*

Maniora, J. (2018). Mismanagement of sustainability: What business strategy makes the difference? Empirical evidence from the USA. *Journal of Business Ethics*, *152*(4), 931–947. https://doi.org/10.1007/s10551-018-3819-0

Marconi, M., Marilungo, E., Papetti, A., & Germani, M. (2017). Traceability as a means to investigate supply chain sustainability: The real case of a leather shoe supply chain. *International Journal of Production Research*, *55*(22), 6638–6652. https://doi.org/10.1080/00207543.2017.1332437

Marshall, C., & Rossman, G. B. (2016). *Designing qualitative research* (6th.edition). Sage.

Martínez-Mesa, J., González-Chica, D. A., Duquia, R. P., Bonamigo, R. R., & Bastos, J. L. (2016). Sampling: How to select participants in my research study? *Anais Brasileiros de Dermatologia*, *91*(3), 326–330. https://doi.org/10.1590/abd1806-4841.20165254

McAdam, R., Miller, K., & McSorley, C. (2019). Toward a contingency theory perspective of quality management in enabling strategic alignment. *International Journal of Production Economics*, *207*, 195–209. https://doi.org/10.1016/j.ijpe.2016.07.003

McKenna, B., Myers, M. D., & Newman, M. (2017). Social media in qualitative research: Challenges and recommendations. *Information and organization*, *27*(2), 87–99. https://doi.org/10.1016/j.infoandorg.2017.03.001

McNarry, G., Allen-Collinson, J., & Evans, A. B. (2019). Reflexivity and bracketing in

sociological phenomenological research: researching the competitive swimming lifeworld. *Qualitative Research in Sport, Exercise and Health*, *11*(1), 138-151. https://doi.org/10.1080/2159676X.2018.1506498

Merkuryeva, G., Valberga, A., & Smirnov, A. (2019). Demand forecasting in pharmaceutical supply chains: A case study. *Procedia Computer Science*, *149*, 3–10. https://doi.org/10.1016/j.procs.2019.01.100

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation* (4th edition). John Wiley & Sons Inc.

Mishra, S., Devi, S. K. K., & Narayanan, B. M. K. (2019). People & process dimensions of automation in business process management industry. *International Journal of Engineering and Advanced Technology*, *8*(6), 2465–2472. https://doi.org/10.35940/ijeat.F8555.088619

Modi, K., Lowalekar, H., & Bhatta, N. M. K. (2019). Revolutionizing supply chain management the theory of constraints way: a case study. *International Journal of Production Research, 57*(11), 3335–3361. https://doi-org/10.1080/00207543.2018.1523579

Mohammaddust, F., Rezapour, S., Farahani, R. Z., Mofidfar, M., & Hill, A. (2017). Developing lean and responsive supply chains: A robust model for alternative risk mitigation strategies in supply chain designs. *International Journal of Production Economics*, *183*, 632–653. https://doi.org/10.1016/j.ijpe.2015.09.012

Nadeem, A., Abedin, B., Cerpa, N., & Chew, E. (2018). Editorial: Digital transformation

& digital business strategy in electronic commerce: The role of organizational capabilities. *Journal of Theoretical and Applied Electronic Commerce Research, 13*(2), I–VIII. https://doi.org/10.4067/S0718-18762018000200101

Nagarajan, G., & Babu, D. B. (2019). Predictive analytics on big data—An overview. *Informatica*, *43*(4). https://doi.org/10.31449/inf.v43i4.2577

Narayanan, H., Luna, M. F., Stosch, M., Cruz Bournazou, M. N., Polotti, G., Morbidelli, M., Butté, A., & Sokolov, M. (2020). Bioprocessing in the digital age: The role of process models. *Biotechnology Journal*, *15*(1), 1900172. https://doi.org/10.1002/biot.201900172

National Commission for the Protection of Human Subjects and Biomedical and Behavioral Research. (1979). *Belmont Report Ethical principles and guidelines for the protection of human subjects of research*. U.S. Department of Health and Human Services. https://www.gov/ohrp/humansubjects/guidance/Belmont.html

Nguyen, H., Onofrei, G., Fynes, B., & Azadnia, A. H. (2020). Quality and lean practices synergies: A swift even flow perspective. *International Journal of Quality & Reliability Management*. https://doi.org/10.1108/IJQRM-11-2019-0360

Niemand, T., Rigtering, J. P. C., Kallmünzer, A., Kraus, S., & Maalaoui, A. (2020). Digitalization in the financial industry: A contingency approach of Entrepreneurial orientation and strategic vision on digitalization. *European Management Journal*. https://doi.org/10.1016/j.emj.2020.04.008

Nolan, S., Hendricks, J., Williamson, M., & Ferguson, S. (2018). Using narrative inquiry to the listen the voices of adolescent mothers in relation to their use of social networking site (SNS). *Journal of Advanced Nursing, 74*, 743–751. https://pubmed.ncbi.nlm.nih.gov/28910502/

Okutmus, E., Kahveci, A., & Kartašova, J. (2015). Using theory of constraints for reaching optimal product mix: An application in the furniture sector. *Intellectual Economics*, *9*(2), 138–149. https://doi.org/10.1016/j.intele.2016.02.005

Onciou, I. (2019). The impact of big data analytics on company performance in supply chain management. *Sustainability*, *11*(18), 4864. https://doi.org/10.3390/su11184864

O'Reilly, C., & Binns, A. J. M. (2019). The three stages of disruptive innovation: Idea generation, incubation, and scaling. *California Management Review*, *61*(3), 49–71. https://doi.org/10.1177/0008125619841878

Osorio, G., & España, K. T. (2020). Operational risk management in the pharmaceutical supply chain using ontologies and fuzzy QFD. *Procedia Manufacturing*, *51*, 1673–1679. https://doi.org/10.1016/j.promfg.2020.10.233

Oyekan, J., Prabhu, V., Tiwari, A., Baskaran, V., Burgess, M., & Mcnally, R. (2017). Remote real-time collaboration through synchronous exchange of digitised human–workpiece interactions. *Future Generation Computer Systems*, *67*, 83–93. https://doi.org/10.1016/j.future.2016.08.012

Pandya, E. J., & Shah, K. V. (2013). Contract manufacturing in pharma industry. *Pharma*

Science Monitor, 4(3), 123–144. https://www.researchgate.net/profile/Ketan-Shah-6/publication/255910123_CONTRACT_MANUFACTURING_IN_PHARMA_INDUSTRY/links/0c960520da512192d9000000/CONTRACT-MANUFACTURING-IN-PHARMA-INDUSTRY.pdf

Paul, S. K., Sarker, R., & Essam, D. (2017). A quantitative model for disruption mitigation in a supply chain. *European Journal of Operational Research*, *257*(3), 881–895. https://doi.org/10.1016/j.ejor.2016.08.035

Peregrine, P. N. (2018). Sampling theory. In S. L. López Varela (Ed.), *The Encyclopedia of Archaeological Sciences* (pp. 1–3). John Wiley & Sons. https://doi.org/10.1002/9781119188230.saseas0516

Peticca-Harris, A., deGama, N., & Elias, S. R. S. T. A. (2016). A dynamic process model for finding informants and gaining access in qualitative research. *Organizational Research Methods*, *19*(3), 376–401. https://doi.org/10.1177/1094428116629218

Pontinha, V. M., Wagner, T. D., & Holdford, D. A. (2020). Point-of-care testing in pharmacies – An evaluation of the service from the lens of resource-based theory of competitive advantage. *Journal of the American Pharmacists Association*, S1544319120305549. https://doi.org/10.1016/j.japh.2020.11.005

Porter, M. E. (1980). *Competitive strategy: Techniques for analyzing industries and competitors*. The Free Press.

Prester, J., Buchmeister, B., & Palcic, I. (2018). Effects of advanced manufacturing

technologies on manufacturing company performance. *Strojniski Vestnik – Journal of Mechanical Engineering*, *64*(2018), 763-771. https://doi.org/10.5545/svjme.2018.5476

Price, J. H., & Murnan, J. (2004). Research limitations and the necessity of reporting them. *American Journal of Health Education, 35*(2), 66-67. http://doi.org/10.1080/19325037.2004.10603611

Properzi, F., & Cruz, J. M. (2020). Intelligent drug supply chain: Creating value from AI. https://www2.deloitte.com/ch/en/pages/life-sciences-and-healthcare/articles/intelligent-drug-supply-chain.html/

Pundir, A. K., Jagannath, J. D., & Ganapathy, L. (2019). Improving supply chain visibility using Internet of things. *2019 IEEE 9th Annual Computing and Communication Workshop and Conference (CCWC)*, 0156–0162. https://doi.org/10.1109/CCWC.2019.8666480

Radoglou, P. I., Sarigiannidis, P. G., & Moscholios, I. D. (2019). Securing the internet of things: Challenges, threats, and solutions. *Internet of Things*, *5*, 41–70. https://doi.org/10.1016/j.iot.2018.11.003

Raman, S., Patwa, N., Niranjan, I., Ranjan, U., Moorthy, K., & Mehta, A. (2018). Impact of big data on supply chain management. *International Journal of Logistics Research and Applications*, *21*(6), 579–596. https://doi.org/10.1080/13675567.2018.1459523

Ramaswamy, R. (2021). Make a compelling case for your digital supply chain

transformation. https://www.gartner.com/smarterwithgartner/make-a-compelling-case-for-your-digital-supply-chain-transformation

Ridder, H. (2017). The theory contribution of case study research designs. *Business Research, 10*, 281–305. https://doi.org/10.1007/s40685–017–0045–z

Ritter, T., & Pedersen, C. L. (2020). Digitization capability and the digitalization of business models in business-to-business firms: Past, present, and future. *Industrial Marketing Management, 86*, 180–190. https://doi.org/10.1016/j.indmarman.2019.11.019

Romero-Silva, R., Santos, J., & Hurtado, M. (2018). A note on defining organizational systems for contingency theory in OM. *Production Planning & Control*, *29*(16), 1343–1348. https://doi.org/10.1080/09537287.2018.1535146

Ross, P. K., & Blumenstein, M. (2015). Cloud computing as a facilitator of SME entrepreneurship. *Technology Analysis & Strategic Management*, *27*(1), 87–101. https://doi.org/10.1080/09537325.2014.951621

Sabouhi, F., Pishvaee, M. S., & Jabalameli, M. S. (2018). Resilient supply chain design under operational and disruption risks considering quantity discount: A case study of pharmaceutical supply chain. *Computers & Industrial Engineering, 126*, 657–672. https://doi.org/10.1016/j.cie.2018.10.001

Santiago-Delefosse, M., Gavin, A., Bruchez, C., Roux, P., & Stephen, S. L. (2016). Quality of qualitative research in the health sciences: Analysis of the common criteria present in 58 assessment guidelines by expert users. *Social Science &*

Medicine, *148*, 142–151. https://doi.org/10.1016/j.socscimed.2015.11.007

Saunders, M. N. K., Lewis, P., & Thornhill, A. (2019). *Research methods for business students* (8th edition). Pearson Education Limited.

Saxena, N., Thomas, I., Gope, P., Burnap, P., & Kumar, N. (2020). PharmaCrypt: Blockchain for critical pharmaceutical industry to counterfeit drugs. *Computer, 53*(7), 29–44. https://doi.org/10.1109/MC.2020.2989238

Schallmo, D., Williams, C. A., & Lohse, J. (2019). Digital strategy—Integrated approach and generic options. *International Journal of Innovation Management*, *23*(08), 1940005. https://doi.org/10.1142/S136391961940005X

Schmenner, R. W. (2015). The pursuit of productivity. *Production and Operations Management*, *24*(2), 341–350. https://doi.org/10.1111/poms.12230

Schmenner, R. W., & Swink, M. L. (1998). On theory in operations management. *Journal of Operations Management, 17*(1), 97–113. https://doi.org/10.1016/S0272-6963/00028-X

Schoonenboom, J., & Johnson, R. B. (2017). How to construct a mixed methods research design. *KZfSS Kölner Zeitschrift Für Soziologie Und Sozialpsychologie*, *69*(S2), 107–131. https://doi.org/10.1007/s11577-017-0454-1

Schrauf, S., & Berttram, P. (2016). How digitization makes the supply chain more efficient, agile, and customer-focused. https://www.strategyand.pwc.com/gx/en/insights/2016/industry-4-digitization/industry40.pdf

Schwer, K., Hitz, C., Wyss, R., Wirz, D., & Minonne, C. (2018). Digital maturity variables and their impact on the enterprise architecture layers. *Problems and Perspectives in Management*, *16*(4), 141–154. https://doi.org/10.21511/ppm.16(4).2018.13

Sebastian, I. M., Ross, J. W., Beath, C., Mocker, M., Moloney, K. G., & Fonstad, N. O. (2020). How big old companies navigate digital transformation. *Strategic Information Management* (5th ed., pp. 133–150). Routledge. https://doi.org/10.4324/9780429286797-6

Segars, A. H. (2018). Seven technologies remaking the world. *MIT Sloan Management Review. 58*, 1–21.https://sloanreview.mit.edu/projects/seven-technologies-remaking-the-world/

Seitz, S. (2016). Pixilated partnerships, overcoming obstacles in qualitative interviews via Skype: A research note. *Qualitative research, 16*(2), 229-235. https://journals.sagepub.com/doi/abs/10.1177/1468794115577011?journalCode=q

Seyedghorban, Z., Tahernejad, H., Meriton, R., & Graham, G. (2020). Supply chain digitalization: Past, present and future. *Production Planning & Control*, *31*(2–3), 96–114. https://doi.org/10.1080/09537287.2019.1631461

Sharma, D. K., Gupta, P., & Priety, P. (2020a). Internet of Things: The new Rx for pharmaceutical manufacturing and supply chains. In *an Industrial IoT Approach for Pharmaceutical Industry Growth* (pp. 257–288). Elsevier. https://doi.org/10.1016/B978-0-12-821326-1.00010-3

Sharma, R., Kamble, S. S., Gunasekaran, A., Kumar, V., & Kumar, A. (2020b). A systematic literature review on machine learning applications for sustainable agriculture supply chain performance. *Computers & Operations Research*, *119*, 104926. https://doi.org/10.1016/j.cor.2020.104926

Shekarian, M., Reza Nooraie, S. V., & Parast, M. M. (2020). An examination of the impact of flexibility and agility on mitigating supply chain disruptions. *International Journal of Production Economics*, *220*, 107438. https://doi.org/10.1016/j.ijpe.2019.07.011

Singh, R., Dwivedi, A. D., & Srivastava, G. (2020). Internet of things based blockchain for temperature monitoring and counterfeit pharmaceutical prevention. *Sensors*, *20*(14), 3951. https://doi.org/10.3390/s20143951

Singh, R. K., Kumar, R., & Kumar, P. (2016). Strategic issues in pharmaceutical supply chains: A review. *International Journal of Pharmaceutical and Healthcare Marketing*, *10*(3), 234–257. https://doi.org/10.1108/IJPHM-10-2015-0050

Sivarajah, U., Irani, Z., Gupta, S., & Mahroof, K. (2020). Role of big data and social media analytics for business-to-business sustainability: A participatory web context. *Industrial Marketing Management*, *86*, 163–179. https://doi.org/10.1016/j.indmarman.2019.04.005

Sodhi, M. S., & Tang, C. S. (2018). Corporate social sustainability in supply chains: A thematic analysis of the literature. *International Journal of Production Research*, *56*(1–2), 882–901. https://doi.org/10.1080/00207543.2017.1388934

Sohn, B. K., Thomas, S. P., Greenberg, K. H., & Pollio, H. R. (2017). Hearing the voices of students and teachers: A phenomenological approach to educational research. *Qualitative Research in Education*, *6*(2), 121. https://doi.org/10.17583/qre.2017.2374

Sovacool, B. K., Axsen, J., & Sorrell, S. (2018). Promoting novelty, rigor, and style in energy social science: Toward codes of practice for appropriate methods and research design. *Energy Research & Social Science*, *45*, 12–42. https://doi.org/10.1016/j.erss.2018.07.007

Spiers, J., Morse, J. M., Olson, K., Mayan, M., & Barrett, M. (2018). Reflection/commentary on a past article: "Verification strategies for establishing reliability and validity in qualitative research." *International Journal of Qualitative Methods, 17*(1), 1-2. https://doi.org/10.1177/1609406918788237

Spillane, A., Larkin, C., Corcoran, P., Matvienko-Sikar, K., & Arensman, E. (2017). What are the physical and psychological health effect of suicide bereavement on family members? Protocol for an observational and interview mixed-methods study in Ireland. *BMJ Open*, *71* (3), 1–8. https://doi.org/10.1136/bmjopen-2016-01470709

Stewart, H., Gapp, R., & Harwood, I. (2017). Exploring the alchemy of qualitative management research: Seeking trustworthiness, credibility and rigor through crystallization. *The Qualitative Report, 22*, 1–19. https://nsuworks.nova.edu/tqr/vol22/iss1/1/

Tobi, H., & Kampen, J. K. (2018). Research design: The methodology for Interdisciplinary research framework. *Quality & Quantity*, *52*(3), 1209–1225. https://doi.org/10.1007/s11135-017-0513-8

Tong, A., & Dew, M. A. (2016). Qualitative research in transplantation: Ensuring relevance and rigor. *Transplantation*, *100*(4), 710–712. https://doi.org/10.1097/TP.0000000000001117

Tongsuksai, S., & Mathrani, S. (2020). Integrating cloud ERP systems with new technologies based on industry 4. 0: A systematic literature review. *2020 IEEE Asia-Pacific Conference on Computer Science and Data Engineering (CSDE)*, 1–6. https://doi.org/10.1109/CSDE50874.2020.9411570

Trojanowska, J., & Dostatni, E. (2017). Application of the theory of constraints for project management. *Management and Production Engineering Review*, *8*(3), 87–95. https://doi.org/10.1515/mper-2017-0031

Tyagi, P., & Agarwal, G. (2014). Supply chain challenges among BRICS countries: A literature review. *American Journal of Engineering Research, 3*, 284–290. https://www.researchgate.net/publication/338356900_Supply_Chain_Challenges

U.S. Department of Commerce- International Trade Administration. (2017). *2016 ITA Pharmaceuticals Top Market Report.*

U.S. Federal Drug Administration. (2018). *Report on Drug Shortages for Calenda Year 2017- Required by Section 506C-1 of the Federal Food, Drug, and Cosmetic Act., Maryland.* https://www.fda.gov/media/113991/download

Vidgen, R., Shaw, S., & Grant, D. B. (2017). Management challenges in creating value from business analytics. *European Journal of Operation Research, 261*(2), 626–639. https://www.sciencedirect.com/science/article/pii/S0377221717301455

Viegas, C. V., Bond, A., Vaz, C. R., & Bertolo, R. J. (2019). Reverse flows within the pharmaceutical supply chain: A classificatory review from the perspective of end-of-use and end-of-life medicines. *Journal of Cleaner Production*, *238*, Article 117719. https://doi.org/10.1016/j.jclepro.2019.117719

Vincent, R. (2020). The high cost of prescription drugs: Causes and solutions. *Blood Cancer Journal*, *10*(6), 71. https://doi.org/10.1038/s41408-020-0338-x

Wa-Mbaleka, S. (2020). The researcher as an instrument. In A. P. Costa, L. P. Reis, & A. Moreira (Eds.), *Computer supported qualitative research* (Vol. 1068, pp. 33–41). Springer International Publishing. https://doi.org/10.1007/978-3-030-31787-4_3

Wang, W., Xue, K., & Sun, X. (2017). Cost sharing in the prevention of supply chain disruption. *Mathematical Problems in Engineering*, *2017*, 1–8. https://doi.org/10.1155/2017/7843465

Weill, P., & Woerner, S. L. (2018). Is your company ready for a digital future? *MIT Sloan Management Review, 59*, 21–25. https://sloanreview.mit.edu/article/is-your-company-ready-for-a-digital-future/

Westerman, G. (2018). Your company doesn't need a digital strategy. *MIT Sloan Management Review, 59*(3), 10–12. https://sloanreview.mit.edu/issue/2018-spring/

Williams, P., Ashill, N., & Naumann, E. (2017). Toward a contingency theory of CRM adoption. *Journal of Strategic Marketing*, *25*(5–6), 454–474. https://doi.org/10.1080/0965254X.2016.1149211

Wilson, V. (2014). Research methods: Triangulation. *Evidence Based Library and Information Practice*, *9*(1), 74–75. https://doi.org/10.18438/B8WW3X

Witkowski, K. (2017). Internet of things, big data, industry 4. 0 – innovative solutions in logistics and supply chains management. *Procedia Engineering*, *182*, 763–769. https://doi.org/10.1016/j.proeng.2017.03.197

Wolgemuth, J. R., Hicks, T., & Agosto, V. (2017). Unpacking assumptions in research synthesis: A critical construct synthesis approach. *Educational Researcher*, *46*(3), 131–139. https://doi.org/10.3102/0013189X17703946

Wu, L., Yue, X., Jin, A., & Yen, D. C. (2016). Smart supply chain management: A review and implications for future research. *The International Journal of Logistics Management, 27*(2), 395–417. https://doi.org/10.1108/IJLM-02-2014-0035

Yaqoob, I., Hashem, I. A. T., Gani, A., Mokhtar, S., Ahmed, E., Anuar, N. B., & Vasilakos, A. V. (2016). Big data: From beginning to future. *International Journal of Information Management*, *36*(6), 1231–1247. https://doi.org/10.1016/j.ijinfomgt.2016.07.009

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th edition). Sage.

Yin, Y., Stecke, K. E., Swink, M., & Kaku, I. (2017). Lessons from *seru* production on manufacturing competitively in a high-cost environment. *Journal of Operations Management*, *49–51*(1), 67–76. https://doi.org/10.1016/j.jom.2017.01.003

Yousefi, N., & Alibabaei, A. (2015). Information flow in the pharmaceutical supply chain. *Iranian Journal of Pharmaceutical Research*, *14*(4). https://doi.org/10.22037/ijpr.2015.1764

Zabihollah, R. (2021). *Business sustainability: Profit with purpose focus*. Business Expert Press.

Zadvinskis, I. M., Smith, J. G., & Yen, P. Y. (2018). Nurses' experience with health information technology: Longitudinal qualitative study. *JMIR Medical Informatics, 6* (2). https://pubmed.ncbi.nlm.nih.gov/29945862/

Zemankova, A. (2019). Artificial intelligence in audit and accounting: Development, current trends, opportunities and threats - literature review. *2019 International Conference on Control, Artificial Intelligence, Robotics & Optimization (ICCAIRO)*, 148–154. https://doi.org/10.1109/ICCAIRO47923.2019.00031

Zhan, Y., & Tan, K. H. (2020). An analytic infrastructure for harvesting big data to enhance supply chain performance. *European Journal of Operational Research*, *281*(3), 559–574. https://doi.org/10.1016/j.ejor.2018.09.018

Zissis, D., Saharidis, G. K. D., Aktas, E., & Ioannou, G. (2018). Emission reduction via supply chain coordination. *Transportation Research Part D: Transport and Environment*, *62*, 36–46. https://doi.org/10.1016/j.trd.2018.01.014

Appendix A: Interview Protocol

What I will do	What I will say – script
Introduce the interview and set the stage	Hello, our objective is to explore the strategies used by some pharmaceutical managers to digitalize the integrated supply chain system to increase their profitability. I will ask a few questions about what you do. There are no right or wrong answers; please answer as wholly and as truthfully as possible.
Get permission to record the interview	I want to make sure I capture your thoughts accurately. Is it ok if I record our conversation and keep short notes? The information will remain confidential.
Start interview Watch for non-verbal queues -Paraphrase as needed - Ask follow-up and probing questions	1. What strategies did you select to digitalize your organizations' supply chain system? 2. What were the digital processes and tools that you selected to digitalize your supply chain system? 3. What were the principal criteria for selecting these digital tools and strategies? 4. How did you assess the effectiveness of your strategies for meeting your expectations? 5. What were the key barriers to implementing the strategies for digitizing your organizations' supply chain? 6. How did you address the key barriers or constraints to implementing your organizations' digital strategies for mitigating disruptions in the supply chain system? 7. Based on your experience, how have these digital supply chain strategies helped you improve your organizations' performance? 8. What additional information would you like to share concerning the strategies you developed and implemented to digitalize your organizations' integrated supply chain system?
Wrap up interview	These are all the questions I have for you today.
Schedule follow-up member checking interview	I will transcribe your responses, write a summary of our discussion, and send it to you next week. Can we schedule a short conversation on {Date} to make sure I captured the information entirely and correctly understood your strategies? Is there a good day for our follow-up?
Thank Participant for their participation	Thank you for your time today. I learned a lot about you and your company.

Member Checking

What I will do	What I will say – script
Get permission to Record	I want to make sure I capture your thoughts accurately. Is it ok if I record our conversation and keep short notes? The information will remain confidential.
Make sure they have received a summary of the interpretations.	I sent a summary of our last discussion on {date}. Did you receive it and have a chance to look it over?
Ensure accuracy and completeness	Read each question and Ask: Did I understand you correctly? Did I miss anything? Is there something you would like to add?
Expand and verify **Prepare to probe and ask clarifying questions**	I want to discuss X in more detail. Can you elaborate on it?
Thank Participant for their participation	Thank you for your time today. I learned a lot about you and your company. I will send a copy of the final version of the study once it is completed.

Appendix B: Interview Questions

1. What strategies did you select to digitalize your organizations' supply chain system?
2. What were the digital processes and tools that you selected to digitalize your supply chain system?
3. What were the principal criteria for selecting these digital tools and strategies?
4. How did you assess the effectiveness of your strategies for meeting your expectations?
5. What were the key barriers to implementing the strategies for digitizing your organizations' supply chain?
6. How did you address the key barriers or constraints to implementing your organizations' digital strategies for mitigating disruptions in the supply chain system?
7. Based on your experience, how have these digital supply chain strategies helped you improve your organizations' performance?
8. What additional information would you like to share concerning the strategies you developed and implemented to digitalize your organizations' integrated supply chain system?