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DIGITAL SOLUTIONS FOR SUPPLY CHAIN MANAGEMENT IN HEALTHCARE

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ABSTRACT

Against the backdrop of the fourth revolution and the COVID-19 pandemic, many companies have started to rethink their supply chains to increase their flexibility and efficiency to ensure their 'survival'. As a result, the concept of digital supply chain has gained more attention. The concept of digital supply chain can increase the sustainability of logistics operations as it offers more tools for visualization, monitoring and forecasting.

Healthcare is on the cusp of radical change into a new era of intelligent and connected healthcare called Health Care 4.0. Healthcare organizations are integrating disruptive technologies into their supply chains, ushering in the fourth industrial revolution - Healthcare Supply Chain 4.0. Healthcare Supply Chain 4.0 incorporates the sustainable practices of Industry 4.0 technologies. Thus, a comprehensive, intelligent, and interconnected healthcare society is emerging, leading to the Healthcare 4.0 paradigm.

So, the aim of the study is to substantiate the relevance of the application of technological innovations in improving health care in modern times. As the methodological basis of the study, it is shown that the main goal is the transition from traditional healthcare to digital healthcare. The application of the study is to increase the effective and sustainable use of digital solutions in improving the healthcare supply chain. The findings of the study will serve to improve the healthcare supply chain, deepening the reforms on the application of high technology in this field. The originality and scientific novelty of the study is that the features and directions of application of Industry 4.0 platform components and other innovative technologies at different levels of the healthcare supply chain have been explored.

INTRODUCTION

Supply chain (SC) is defined as extractive, manufacturing, commercial, service companies and their customers interacting in different functional areas between which product, information and financial flows occur (Witkowski, 2003). SC is a network of organizations that are involved, through upstream and downstream linkages, in various processes and activities that create value in the form of products and services in the hands of the end consumer (Christopher, 2016). Supply chain management (SCM) is the management of upstream and

downstream relationships with suppliers and consumers to provide superior customer value at lower cost to the supply chain. Since the term was introduced in the early 1980s, SCM has gained widespread prominence and, through decades of theoretical and practical wisdom, has become a mainstay of business. With a particular focus on stakeholder interactions, the wealth of acquired knowledge in SCM provides a unique opportunity to understand, evaluate and improve complex ecosystems such as healthcare systems (Betcheva et al., 2020). The supply chain in this industry is a major cost driver and therefore attracts close attention from industry stakeholders.

Healthcare SCM is the process of managing, distributing, monitoring a product or service in a hospital that deals with suppliers, customers, and other channel actors (Adnan and Sahroni, 2014). SCM in healthcare is a complex task. There are two critical issues that need to be managed effectively, such as health services and costs, to ensure the best quality. Sustainable supply chain management in health care includes information, procurement, suppliers, service providers, internal and external customers and end users. Economic sustainability can be perceived as the goal of controlling costs, movement and delivery of goods and services on a time scale that starts with the supplier and ends with the end user, integrating processes (Dau, et al., 2019).

Industry 4.0 is a concept that encompasses automation and information technology, as well as some of the major technological innovations in these areas. Industry 4.0 initiatives help industries implement measures to protect and control the environment and reduce supply chain risks by turning them into sustainable supply chains. Sustainable supply chain aims to design, plan, and operate supply chains that can guarantee market needs, considering not only profit but also environmental and social concerns (Dau et al., 2019).

The healthcare SC lags far behind other industries in terms of efficiency and adoption of best practice. The current trend shows that the industry struggles to meet SC timelines. The main weakness remains the fact that each part of the SC operates independently, creating uncoordinated activities that prevent them from functioning as a unified system. Managers could bridge this gap and improve SC efficiency in healthcare by implementing digitalization initiatives. However, the uneven, unconnected digitalization of practices already implemented in the health sector makes it difficult to maximize the potential of these initiatives.

HELATHCARE SUPPLY CHAIN MANAGEMENT

In healthcare organisations, the supply chain is a new way of conceptualising healthcare supply management. The SC is defined as 'a virtual network that facilitates the movement of a product from its production, distribution and consumption' in healthcare from supplier to end-user with the aim of improving clinical outcomes while controlling costs. This definition identifies three critical aspects of the SC: finance, materials and information, and these aspects are embodied in three healthcare SC constructs: affordability, access and awareness. SCM is more complex in healthcare than in other sectors because of the impact on human health, which requires adequate and accurate medical supplies in accordance with patient needs (Jahantigh and Malmir, 2015). SCM is a concept, strategy and approach that has proven its value and excellence in the management of healthcare facilities around the world. Observations show that hospitals that have successfully implemented SCM have recorded a 50% reduction in inventory, a 40% increase in on-time delivery, a doubling of stock returns combined with a nine-fold reduction in out-of-stock rates (Jahantigh and Malmir, 2015).

SCM in healthcare should ensure full end-to-end visibility between suppliers, manufacturers, distributors and customers. The healthcare SC involves the movement of many different types of products and the involvement of multiple stakeholders. The primary objective of the healthcare SC is the timely delivery of products to meet the needs of suppliers (Afoakwah et al., 2023). All stakeholders in the health supply chain, including actors, organisations and individuals, are shown in Table 1.

Table 1. Stakeholders in healthcare supply chain

Category	Stakeholders
End consumers	Patients, patient families, and populations
Care providers	Hospitals, clinics, ambulance services, mental health, public health, physicians, nurses, technicians, managers, paramedics, dentists, psychiatrists, et al.
Intermediaries	Group purchasing organizations, pharmacy benefit managers
Pharmaceutical providers	Innovators (such as research institutes and academia), biotechnology firms, clinical trial sites, raw material suppliers, pharmaceutical manufacturers, distributors, wholesalers, pharmacies (retailers)
Equipment & ancillaries	Medical, diagnostic, and surgical devices, capital equipment, office equipment, vaccines, blood, organs
Contractors	Contract research organizations, contract manufacturing organizations, site management organizations, clinical commissioning groups
Policy makers	Governments, regulators, patent, and trademark offices, quality monitors, advisory committees
Payers	Insurance companies, national and local governments, employers, venture capital firms, communities, nonprofit organizations, foundations and charities, patients, patient families
Support services	Research institutes, information technology systems and electronic health records, decision support systems

At the heart of effective and efficient SCM is supply chain thinking, which encompasses three key aspects: customer orientation, systems approach and strategic orientation. Customer orientation ensures that the creation of customer value is a key driver of SCM activities. The systems approach looks at organisations in the SC as an end-to-end, integrated unit, and the strategic orientation of each individual organisation aligns the organisation's intra- and inter-firm goals and capabilities with those of the SC (Betcheva et al., 2020).

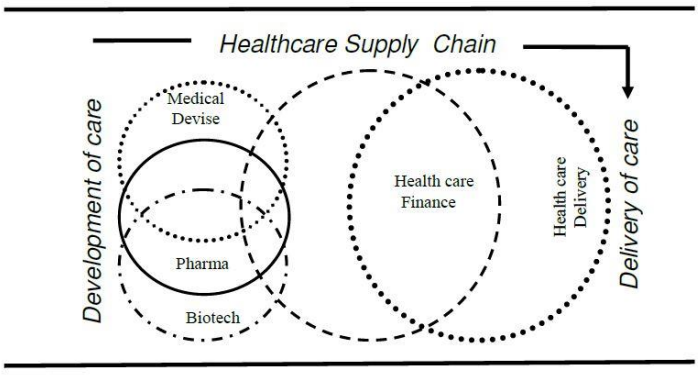

Figure 1. Supply chain for the healthcare sector.

As shown in Figure 1, at the top of the health services supply chain are circles representing the industries associated with the development of key elements of the care package, namely the medical device, pharmaceutical and biotechnology industries. At the bottom of the supply chain

is a circle representing the healthcare delivery industry, consisting of organisations such as hospitals, clinics and home health services. In the centre is the circle representing the healthcare financing industry, which includes organisations such as insurance companies and banks offering medical savings accounts. The intersection points of the circles represent the interdependence between the constituent sectors of the healthcare SC (Jahantigh and Malmir, 2015).

Historically, SC in healthcare has usually been associated with the procurement and logistics of health products and services. However, recent developments in healthcare have made this understanding too narrow. For example, a new way of thinking, illustrated by the widespread adoption of technology, an emphasis on integrated care delivery and the alignment of stakeholders' interests through new reimbursement schemes, has pushed health authorities to adopt broader SC concepts. In addition, the complexity of interactions between health care stakeholders and the isolated nature of health care delivery create an opportunity to understand, evaluate and improve this dormant ecosystem in a systematic, holistic manner. Thus, following the path of traditional SC, which has expanded the field of procurement to the prevailing view of SCM, SCM in health care has a much broader scope than the usual procurement and logistics-focused definition (Betcheva et al., 2020).

There are two well-known models in supply chain organisation: Supply Chain Operations Reference (SCOR) model and Global Supply Chain Forum (GSCF) model. The SCOR approach takes a transactional perspective and defines five core business processes as relating to supply chain management from a transactional perspective, thereby addressing issues of transactional efficiency, cost reduction and asset utilisation.

The following 5 processes are included in the SCOR model:

1) Plan (demand and supply planning and management);
2) Source (the raw materials);
3) Make (plan production and produce);
4) Deliver (all steps in the order to payment cycle);
5) Return (the raw materials to the supplier or receive returned goods from the customer) (Hubner and Elmhorst, 2008).

As their names suggest, these processes are production-related. For this reason, when applying the SCOR model to health care, it is recommended to reduce the number of relevant processes - planning (if possible), source (medical supplies), providing patient care (which would be a mixture of production and delivery in the original model) and return (defective supplies). Because of its industrial origin, the entire SCOR process is based on a proper planning process. As a result, SCOR processes can be partially transferred to healthcare.

In contrast to SCOR, GSCF primarily looks at relationship management and economic value added and focuses less on transactional efficiency. It thus emphasises the overall corporate strategy rather than the transactional strategy as SCOR does. GSCF defines eight processes that overlap with SCOR. Each of these processes consists of strategic and operational sub-processes. These include:

1) Customer relationship management;
2) Customer service management;

3) Demand management;
4) Order fulfilment;
5) Manufacturing flow management;
6) Product development and commercialization;
7) Supplier relationship management;
8) Returns management (Hubner and Elmhorst, 2008).

The main differences from SCOR are "supplier and customer relationships" and "product development and commercialisation". Like SCOR, the concept of GSCF originated in manufacturing, so similar problems arise when the approach is transferred to health care without change (Hubner and Elmhorst, 2008).

Observations show that different national and regional healthcare systems use several models of care delivery. Three trends underlying all three aspects of healthcare SCM should now be noted. Thus, they seek to maximise the overall health and quality of life of patients and to improve patient outcomes by enhancing client-centredness. These trends include:

1) Shifting the focus of treatment from treatment to prevention
2) Shifting care closer to the patient's home
3) Shift from extensive treatment to personalised/precise medicine (Betcheva et al., 2020).

Changes brought about by digital health, artificial intelligence, blockchain and other health innovations are bringing a new vision for the concept of health services to the systems approach. As a result, new variations in models and strategies in healthcare delivery, healthcare SCM and new trends are being observed that adapt to the changing goals and priorities of stakeholders.

DIGITALIZATION OF HEALTHCARE SUPPLY CHAIN

The digital revolution is rapidly and fundamentally changing the way individuals and organizations do business, including the important business of providing healthcare services. Doctors, hospitals, and health systems are taking steps to meet the expectations of digitally connected consumers for superior patient care. In addition, megatrends and customer expectations are changing the game. Beyond the need to adapt, SCs can reach new levels of operational efficiency, leverage new digital SC business models, and transform the company into a digital SC. To develop these trends and cope with the changed requirements, SCs must become much faster, more granular, and much more accurate (Deloitte, 2018; McKinsey&Company, 2016).

Digitalisation of the SC provides a cost-effective way for healthcare providers to deliver the right product to the right patient at the right time - using technological advances to improve data flow and analytics, provider-patient communication, asset tracking and regulatory compliance (Deloitte, 2018).

Digitalisation of the SC brings about the following changes:

- Redesign, including digitisation, standardisation and improvement of business process models;
- Automation and process improvement;

- Development of SC collaboration;
- SC integration;
- Process and product innovation;
- Increased transparency for better decision-making;
- Quicker response to changes in demand and patient needs;
- More choice in decision making in SCM;
- Increasing and maintaining competitive advantage, etc. (Nowicka, 2019a).

The digital transformation of the healthcare SC begins with a digitisation process that improves healthcare facilities and systems from within and integrates data elements across the spectrum of patient care. This process is referred to in several publications as 'core digitization' (Deloitte, 2018). Core digitization is an enterprise-wide exercise in which a common technology platform, often an integrated enterprise resource planning (ERP) system, links and exchanges information from central business functions such as finance, procurement, SC, marketing and others. Unlike traditional business networks, which operate linearly and sequentially, the digital core enables real-time cross-functional communication, connecting business operations to a broader set of ecosystem partners, such as patients, suppliers and similar systems. The digitized core is the foundation upon which higher-order initiatives are built. Digitization of the core can help healthcare providers address SC challenges by disrupting the traditional linear SC (Figure 2.) and creating an interconnected, smarter, faster and more responsive digital SC (Deloitte, 2018).

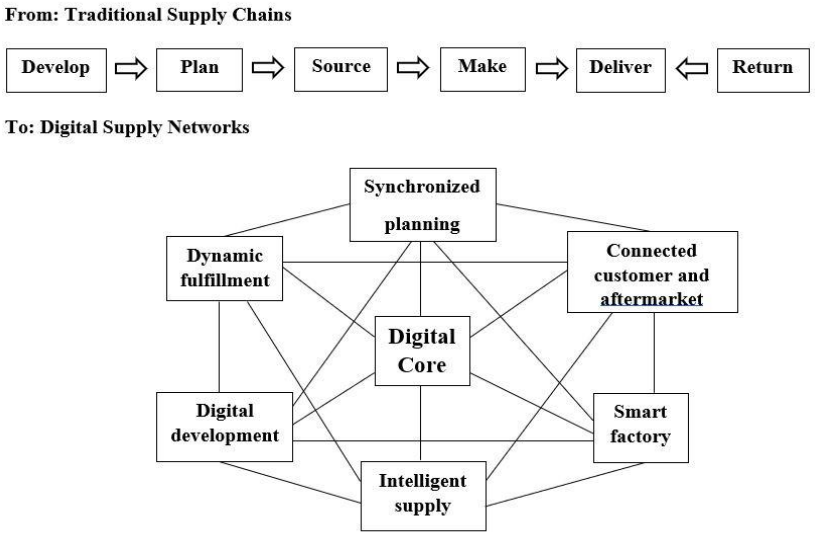

Figure 2. From a traditional supply chain to digitized supply networks

Digital Supply Networks (DSN) can be activated and leveraged through "digital streaming", created to transmit information, goods, and services over physical and digital channels. This provides a flexible, "always-on" stream of data and analytics that helps healthcare facilities and systems achieve productivity, improve operational efficiency and effectiveness, increase patient engagement and create new revenue opportunities. In addition to increased transparency and communication, DSN accelerates processes, reduces costs and better informs business management decisions (Deloitte, 2018).

Digital technologies being implemented in supply chain management are such a new solution. As a result of their implementation, supply chains are undergoing digital transformation. Digital transformation of a supply chain is the transformation of its business model into a model that provides new value based on digital technologies to achieve higher performance within the framework of achieving the strategic objectives set for supply chains (Nowicka, 2019b). Digital transformation of a supply chain is the process and result of a digital transformation strategy adopted first by a company. Subsequently, an operating model and supply chain management model are developed, integrated activities are planned within the functions of sourcing, manufacturing and distribution, measures, and indicators of expected results for individual functions are defined, and a technology ecosystem infrastructure is created to realize the strategic goals of both the enterprise (digital chain leader) and the supply chain (Raab and Griffin-Cryan, 2011).

Two key factors are needed for the transformation to a digital SC - capability and environment. Capabilities relating to digitalization need to be created within the organization, but usually this also requires a targeted recruitment of specialists. The second key prerequisite is the implementation of a two-speed architecture/organization. This means that while the organization and IT landscape is established, an innovation environment with a start-up culture needs to be created. This "incubator" must provide a high degree of organizational freedom and flexibility and state-of-the-art IT systems (two-speed architecture independent of existing legacy systems) to enable rapid cycles of solution development, testing and deployment. Rapid implementation of pilot projects is necessary to get immediate feedback from business on the suitability and impact of solutions, to build excitement and confidence in innovation, and to guide the next development cycles. The "incubator" is the seed of Supply Chain 4.0 in the organization - fast, flexible, and efficient (McKinsey&Company, 2016).

The concept of digitalisation of SC can include traditional technologies such as EDI, eCatalogues and, more recently, sophisticated technologies such as cloud computing, IoT, big data analytics, 3D printing, blockchain and artificial intelligence. These technologies can be used to improve the historical benefits of SCM, i.e. real-time synchronisation of matter flows with information flows, highly personalised production, and flexibility and agility. However, these new technologies will require restructuring the roles of the various SC actors. Digitalisation will also require SC actors to recruit or develop sufficient skills to master new tools and analyse masses of data. Therefore, instead of rushing to acquire new technologies without realising their full potential, it is recommended that organisations prepare plans for the application of these technologies (Beaulieu and Bentahar, 2021).

Several strategies have been identified in relation to the application of new technologies to the digitization of the healthcare SC.

Virtual Centralization of the Supply Chain: Working together using virtual SCM centralization can put hospitals on the path to cost control and improved quality of care. Virtual centralization integrates operations from the perspective of the market rather than that of the healthcare system (Afoakwah et al., 2023). The most mature example is the consolidated service centre (CSC), which is jointly owned and operated by several hospitals and health systems. A CSC combines geographically dispersed groups of hospitals into separate organisations that work together to centralise contracting, purchasing, distribution and logistics operations. The CSC serves not only as a point of contact for sales but also for centralised ordering, purchasing and customer service (Joseph et al., 2013).

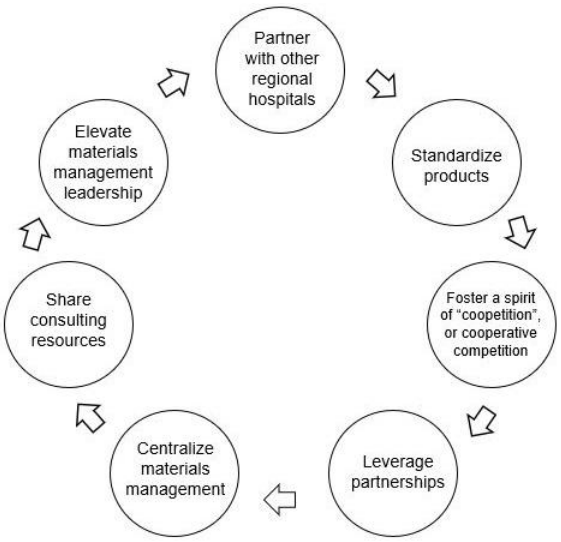

Figure 3. Forming a Consolidated Service Center (CSC)

This innovative approach helps solve crucial problems related to personnel, time, and budgetary constraints. And while saving money is paramount, CSC also provides networking opportunities for participants. The ability to share best practices, resolve conflicts and provide advice helps improve the bottom line. Hospitals will have much more control over product selection and distribution. Consolidation of utilities will lead to significantly improved cost visibility of the hospital supply chain, higher product prices through standardization and pooling of volumes, lower inventory levels, reduced distribution costs and lower inbound freight costs (Afoakwah et al., 2023; Joseph et al., 2013).

Radio Frequency Identification (RFID): It is a technology that allows objects to be connected to the Internet so that they can be tracked and companies can exchange data about them. Unlike the use of barcodes, RFID tags are reliable and do not require line-of-sight identification, eliminating the need for human intervention (Afoakwah et al., 2023). The tags are programmable and contain destination information, weight, and a time stamp. Tags enable the automation of the entire supply chain, including optimization of warehouse space and efficient tracking of goods to reduce costs and improve customer service. RFID tags provide accurate information in real time, forcing applications and processes in all organizations to add value to services (Joseph et al., 2013).

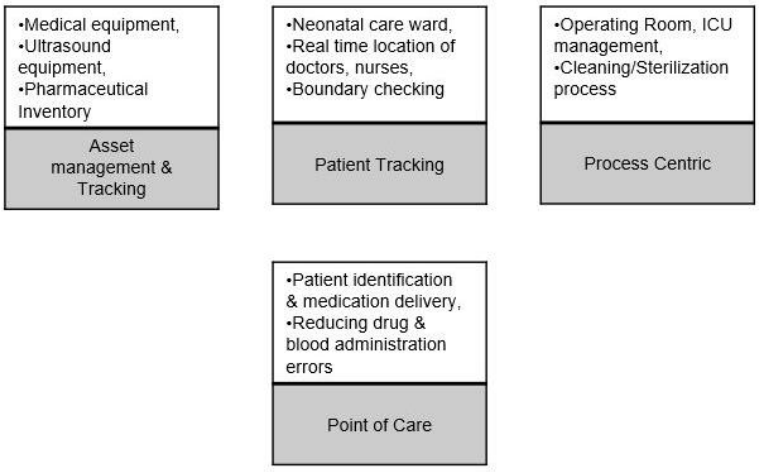

Figure 4. RFID Applications

Real-time tracking of goods throughout the supply chain provides one of the key opportunities for improving customer service. Real-time delivery time information supports just-in-time manufacturing (JIT) and retail, enabling organisations to make strategic decisions.

The following results can be achieved with RFID:

- Improved tracking of high-value goods/assets
- Reduced transport errors in the SC.
- Inventory visibility, accuracy, and efficiency at every stage
- 'Intelligent' feedback for improved production planning and efficient scheduling
- Technology standards for lower costs with higher consumption of tags (economies of scale) (Afoakwah et al., 2023)

However, there are a number of obstacles to the use of RFID in healthcare, including:

- Technical challenges - RFID can interfere with the hospital environment, such as medical equipment. Secondly, RFID systems are not always reliable. The accuracy of RFID reading depends on many factors such as the object with the tag, the location of the tag, the angle of rotation and the reading distance.
- Cost - The cost of RFID includes initial hardware and software costs, training, as well as the ongoing high costs of maintaining and updating the RFID infrastructure.
- Privacy issues - The benefits of using RFID in healthcare facilities are only achievable if patients are confident that the data being transmitted will not be misused. Patient information associated with an RFID tag is highly mobile and confidential.
- Other barriers - Other barriers to the implementation of RFID include lack of organisational support, trust and security issues (Joseph et al., 2013).

Supply Utilization Management: Newly identified savings come not from price reductions, but from eliminating waste, inefficiency, misuse and value mismatch of products, services and technologies used by health-care organizations. The following types of use inconsistencies are common in health care organizations.

- Standardization. Customising products to the exact requirements of customers can reduce an organisation's SC costs. Otherwise, the healthcare organisation's money is wasted on unnecessary features and functions. Therefore, customisation is preferable to standardisation.
- Over-specification. Hospitals often purchase products with components or features that are not medically, legally or functionally necessary.
- Under-specification. Too few components, incorrect components or missing critical features in products, services and technologies are another common cause of non-conforming use.
- Cost inadequacy. Many healthcare organisations inflate their supply budgets with expensive products, services and technologies that are not functionally required. Such organisations often do not look for available cheaper functional alternatives that can meet or exceed customer requirements.
- New technologies. All new technologies must be monitored carefully for at least three months to ensure that they meet or exceed the manufacturer's specifications.

- Older technologies: All technologies, whether lifts, IV pumps, anaesthesia machines or imaging systems, have a certain number of years of service life, and it is uneconomical for a hospital to continue to maintain them beyond their useful life (Afoakwah et al., 2023).

Vendor Managed Inventory: Under Vendor Managed Inventory (VMI), the supplier assumes responsibility for inventory management at the customer and makes decisions about replenishment. To a certain extent, this is based on the information requirements of non-stock inventory systems. The main difference is the transfer of responsibility for inventory management to the supplier, since the ordering process remains automated. For VMI to be successful, accurate information about current stock levels and consumption is necessary. However, providing such information in hospitals can be difficult (Joseph et al., 2013).

Thus, today's healthcare providers are under enormous pressure from growing competition, government regulations, rising costs and demands for higher quality care. Undoubtedly, health-care as a business is becoming extremely complex to manage with diversified departments, changing organisational structures, mergers, employees and multiple information systems around the world. Healthcare organizations must strive to add value to the entire SC by monitoring SC performance. Recent innovations in RFID technology, SC utilisation management and near-centralised SCM are key to the future. Going forward, SC utilisation management is a new best practice that will enable healthcare organisations to look deeper and more fully into their SC costs to generate new and even better SC savings (Afoakwah et al., 2023; Joseph et al., 2013).

CONCLUSIONS

As a result of the changes brought about by the digital economy, supply chain managers are expected to become increasingly innovative and creative to gain a competitive advantage. Traditional supply chain management strategies focus on incremental change, risk avoidance, and cost containment to improve efficiency. Modern supply chain management strategies must take a different approach to beat the competition. This should provide two supply chain management options. The first takes a linear approach to change, emphasizing the importance of predictability, accuracy, reliability, and stability. The second is about learning through nonlinearity, failure, and iteration. Because of the complexity of building supply chains that fit the assumptions of this approach, most managers focus on the first approach to supply chain management, staying in a sort of "comfort zone" about the type of decisions to be made and relying mostly on experience. But the changes taking place require risky but "non-criminal" decisions. As a result, hybrid solutions are emerging in supply chain management, i.e., utilizing both the resources already used and implementing new, innovative solutions that incorporate speed, risk, and preparedness (Griswold, 2017).

The introduction of new technology is known to be a major lever for improving SC operational efficiency. Thanks to the opportunities created by digitalisation, the SC has now become transparent, leading to full visibility of order information from the supplier to the manufacturer, to the distribution centre, to the carrier, to the customer. Researchs show that the potential impact of the Supply Chain 4.0 concept will be enormous in relation to Industry 4.0 in the coming years. So, operational costs are expected to be reduced by up to 30%, lost sales are expected to be reduced by 75% while inventory is reduced by 75%, while SC agility is significantly improved (McKinsey&Company, 2016). A fully computerised inventory will enable a healthcare facility to manage its SC at 'speed of thought'. Tomorrow's SCM will be a fully virtual organisation with the advent of rapid adoption of internet biotechnology, integrated

through efficient data sharing and cost savings at every stage.

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