

Digitalisation in Logistics and Supply Chains

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Abstract— *Recent digitalisation approaches in logistics and supply chain management have changed the way information flows both support and disrupt contemporary operational activity. Digitally supported logistics can improve supply chains in terms of transparency, efficiency and responsiveness and this paper considers how these developments contribute to reducing costs, improving speed and accuracy of data and information, and supporting more robust delivery mechanisms. The wider issue of balance between commercial and intangible measures of performance is also considered. This paper reviews the development of information and communication technologies, their applications in logistics and supply chain operations and suggests possible trajectories which this sector could follow over the coming decade, depending on external and internal influences on development. Developments have included the move to cloud-based systems, enhanced use of digital platforms (e.g., blockchain), the development of Artificial Intelligence and Industry 4.0. Digital transformation can improve an organisation's performance by engendering change through a combination of information, computing, communication, and connectivity technologies [1]. It is a relatively new concept and is both complex and challenging, allowing both for the creation of new value propositions, and the leveraging of data to better understand how product is consumed. This requires an holistic approach to strategy and execution, moving away from disconnected digital approaches. Research suggests that leadership, capability building, empowering workers, upgrading tools, and communication are likely to become key areas of value, and hence for research. Digital platforms have made major advances in advancing the operational efficiency of logistics, cost management and competitive advantage. However, this research suggests that there are particular areas where considerable improvements could be made, e.g., in workforce management, human behavioural inputs and the balance between commercial and intangible measures of performance.*

Keywords—Digitalisation, e-Logistics, digital platforms, AI, Industry 4.0

I. INTRODUCTION

The logistics and supply chain sectors have grown both domestically and internationally in order to facilitate the global flow of goods over the last two decades, with both increased volumes of goods, and associated increases in cargo value. Digitalisation of support systems and the use of Information and Communication Technology (ICT) have had impacts across activities within these sectors including technological developments, cost savings, and increased speed and accuracy of delivery. These have all contributed to the rapid changes taking place [2]. The need for 'seamless integration' across supply chains means that successful

organisations have adopted ICT, adapted to the need for increased automation, and stayed agile and responsive to customer requirements [3].

This paper discusses the effects of digitalisation on contemporary logistics and supply chain management. The paper aims to highlight key drivers of the evolutionary path of e-logistics and supply chain digitalisation. First, a number of technologies are considered which both support existing approaches, but which can act as disruptors to existing systems. Contemporary developments include cloud-based systems, digital platforms, Artificial Intelligence, the Internet of Things, Digital Twins, 5th Generation Communication, Big Data and Industry 4.0. The discussion is then extended to address issues around digital transformation in the supply chain and how the technologies discussed can be effectively used. Research suggests that leadership, capability building, empowering workers, upgrading tools, and communication are likely to become key areas of value. Digital platforms have made major advances in advancing the operational efficiency of logistics, cost management and competitive advantage.

II. DIGITALISATION IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Developments in ICT have increased the quantity and improved the quality of information, and allowed for greater transparency within supply chains, which has in turn led to efficiency gains, improved responsiveness and reduced uncertainty. These developments have also facilitated significant reductions in inventory. Digital infrastructures are evolving rapidly and include satellite positioning technologies and wireless networks. The expansion of low-earth orbit satellite networks such as Starlink, OneWeb and Viasat will enhance the capability for rapid data transfer globally. When linked to mobile devices, ICT systems can provide for the effective and fast transfer of data and information through the supply chain. Customers accepting goods can receive notification of delivery often within minutes of the delivery taking place. The ever-increasing use of ICT is profoundly changing how goods, information, and finance move through the supply chain [4].

Web-based technologies led to the development of 'cloud computing' utilising computing power, data storage and software applications distributed over the internet to provide on-demand services which avoid the need for companies to purchase hardware and software as a direct investment. A key advantage of such systems is the operational strategic flexibility they provide, as well as cost savings through reduced capital expenditure, lower labour and power costs and enhanced security features.

Further, if an organisation wishes to be more closely integrated with other organisations in its network, then this is more easily achievable on the same platform.

Cloud-based systems for logistics have both reduced entry barriers and extended accessibility to organisations involved in logistics and supply chain management. Cloud computing provides scalable flexibility which can provide opportunities for organisations to develop new services and products more efficiently. Examples of the use of cloud computing systems in the logistics sector include more effective lease and ownership models, telematics, and the use of Global Positioning Systems (GPS) for vehicle and trailer tracking [5]. Systems have also been developed to facilitate both logistics and cross-border stakeholder integration. Port Community Systems facilitate co-operation between port users, while Single Window Systems make possible the integration of organisations involved in international trade for cross-border administration and customs processes [6]. Digitalisation has thus been incorporated into logistics and supply chain management, and more recent developments are likely to change practices further.

Successful organisations will be those which leverage emerging technologies including Logistics Platforms, Artificial Intelligence (AI), the Internet of Things (IoTs), Digital Twins, 5G, and predictive analytics. In order to futureproof supply chains, key players will have to integrate such technologies into supply chains and wider networks and systems [7].

A. Logistics Platforms

Globalised manufacturing and distribution require coordination between many actors [8]. Two systems are developing rapidly: blockchain/distributed ledger (DLT) and network platforms. DLT enables supply chain partners to share data which is then visible to all parties on a single platform. Examples of DLT systems for global trade include the Tradelens-Maersk platform, [9] and GSBN [10]. Such platforms offer real-time solutions which overcome the problems of incompatible systems with no one organisation owning the system. They are designed to support effective end-to-end logistics, cargo tracking and routing, and provide real time information on, for example, market prices, freight rates, and schedule reliability.

B. Artificial Intelligence (AI)

Artificial Intelligence (AI) and machine learning are becoming increasingly embedded in commerce and in transport, logistics and supply chain activities, often in conjunction with Robotics and Autonomous Vehicles (AVs) [11]. AI based robotic systems are being adopted to run warehouses, provide automatic pick and re-order stock when inventories run low. Such systems have become prevalent in the operations of retail organisations such as Ocado and Amazon, which use AI-powered robots to provide rapid response times to customer orders [12]. AI also has many applications beyond warehouse automation, for example in retailing, that are likely to impact supply chains and logistics in the future. As the ability of AI technologies are extended so the ability to predict demand trends becomes possible [13]. Amazon's predictive analytics 'anticipatory shipping' tool analyses an individual's shopping history to predict what they will need in the future [14]. Such predictive analytics are advantageous because this allows Amazon

to use standard rather than expedited shipping to deliver such items to the relevant hub, meaning that those items are closer to the customer and therefore less expensive to deliver but with fast order fulfilment times [15]. The introduction of AI is likely to have a major impact on how transport systems operate in the future. One example may be automation in road transport. The use of AI for truck platooning whereby AVs rely on AI software to control all aspects of operation can potentially bring significant commercial benefits [16].

C. Pervasive Computing

'Pervasive computing' whereby devices become context aware, and thereby able to 'understand' their operating environment, has contributed to a concept known as the Internet of Things (IoT). This provides organisations with the ability to remotely monitor, manage and control such devices and thus track goods more accurately and efficiently, with the added benefits of improved decision making and real-time analytics. For supply chains this affords better inventory management and control, real-time routing, dynamic vehicle scheduling, trailer and container management, and shipment tracking, all of which contribute to optimised transport and logistics [2].

D. Digital Twins

Following from the development of the IoT and AI, simulation software, and predictive analytics are now being used to develop Digital Twins (DT). These are digital representations or replicas of, for example, physical devices or systems which provide the ability to explore, stress test and evaluate complexity. In a supply chain context this could be in relation to the connections between computer systems, vehicles, AVs, instruments, drones and robots [8]. In the logistics and supply chain environment DTs could be used to enhance the value chain, including managing container fleets, monitoring shipments and designing logistics systems. DTs of complete supply chains would thus allow for more sophistication in development and testing before implementation [17].

E. Industry 4.0

DT systems are likely to be key facilitators of Industry 4.0 which leverages the previously discussed technologies as well as, for example, Additive Manufacturing, Robotics, Autonomous Vehicles, Drones, and IoT. The connectivity and communication capabilities of these technologies are likely to transform manufacturing, service operations and global supply chain management. Within this concept companies can create value by exploiting incremental advances in technology to re-engineer systems to ensure product fulfilment at the right time for the best price [18].

F. 5th Generation Communication Technology (5G)

5G communication technology and infrastructure offers the potential for significant improvements in cargo handling processes within the supply chain. With the ever-expanding range of 5G technology-enabled equipment and machinery, it will make it very much easier for objects to communicate with each other, potentially making the IoT a reality. 5G technology increases the bandwidth available, improves latency (10

milliseconds), and significantly increases the volume of devices that can be connected [19]. This makes it possible to remotely operate equipment effectively. With the ability to connect hundreds of thousands of sensors, the autonomous and remote operation of devices and machines and networking equipment at scale over a large area will allow a step change in operational capability. The use of 5G in ports is currently being explored in depth [7].

G. Predictive Analytics:

The developments as discussed above will generate huge volumes of 'sensor data', known as 'Big Data'. However, such datasets are too large for existing database software tools to process and advanced predictive analytics tools such as cognitive computing systems will be required. This will potentially fundamentally change how forecasting, inventory management, transport management and human resource management are conducted. Such capabilities provide the opportunity to improve performance, obtain value and gain competitive advantage through better visibility, increased flexibility, and greater integration [20].

III. DIGITAL TRANSITIONING

Digital transitioning can improve an organisation's activities through a combination of the technologies discussed. This could be brought about either from pressure within the organisation or stimulated externally whereby the organisation will have to respond to change in order to remain competitive. However, whether leading or following such changes, improvements in performance and competitive behaviour would be expected. Digital technologies are a key source of disruption within the supply chain and digitalisation has had a significant impact in both raising standards and lowering costs. Organisations leveraging digital platforms face lower market entry barriers, are able to more effectively devise new forms of digital offering, and use sophisticated algorithms to analyse and manipulate data to effectively target their customer base. The key aspect of using digital technologies is to create value for both existing and new customers. Thus, customer needs lead to value creation with the start point of a transitioning strategy which should be derived from the organisation's digital capabilities. Thus, those tasked with leading change will need to appreciate how such technologies work, mediate between the physical supply chain and digital systems, and be able to execute change management [1] [21]. Once a supply chain digital strategy has been envisioned management will need to commit to it. If management and those in transition-specific roles are involved in establishing a clear strategy to execute the transition process, success is more likely. Having an incisive digital leader is recognised as key to transformation success.

A. Strategic Requirements

First, there is a need to understand the state of the current supply chain to determine how transitioning from the current to future state can be achieved. Examining the gaps which exist between these states and understanding the potential challenges and barriers will thus be critical. It can be argued that more successful outcomes occur if supply chain managers start by first visualising what their

future supply chains would look like. Identifying existing problematic areas that must be resolved in order to realise the vision for future is critical. For instance, it might be identified that the existing supply chain has issues such as siloed IT systems or a lack of end-to-end visibility. It is then necessary to understand the organisations current digital capability in terms of its business model; customer perspective; operational approach; employee experience; and the existing digital platform [21]. Further, does the organisation have the necessary data development capability to support its supply chain planning? Developing a digital roadmap and initiatives to address the issue identified will be important. However, supply chain digital transformation will consume significant resources, and the complexities induced by such changes may lead to initiatives taking several years to complete.

B. Supply chain digital transitioning

Approaches to digitalisation include 'exploitation', where existing supply chain approaches are optimised and enhanced for productivity gains and cost cutting, or 'exploration' where new business and supply chain approaches are taken to generate business growth and revenue generation. Approaches being taken in organisations at the forefront of digital development include innovating by experimenting, radical transformation through incremental change and dynamic sustainability using a succession of temporary advantage gains [1][21]. Such organisations tend to be agile and use both new and iterative approaches for bridging the strategy-execution gap. However, given the rapidly changing digital landscape, competitive advantages are not sustained for long periods. Therefore, companies pursuing successive temporary advantages tend to be successful over time. For supply chain organisations there are more constraints because physical supply chain structures and processes need to be taken into consideration. However, the underlying principles are applicable in such organisations. Three areas which are important to consider in any digital development approach are data and technology, people, and process [21].

In respect of data and technology, Big Data (structured and unstructured) is a significant asset for delivering innovations such as personalised products/services, real time supply chain tracking and risk alerts, predictive maintenance and advanced demand sensing and forecasting. Data integrity is important to ensure its usefulness for reliable and accurate decision making. Cybersecurity is also important, and it is necessary for organisations to build cyber resilience into supply chains. Other key issues to consider include the cost of interoperability between systems within and across organisations, and how the focal information is shared with supply chain partners. People issues include leadership and strategy, skills, culture, behavioural change and reward systems.

Digitally aware supply chain leaders and a digitally literate workforce are important in maintaining a competitive edge. Appropriate investment in talent, workforce reskilling and upscaling on a continuous process will be required in order to respond to technological change. Digital transitioning also requires a culture that supports change and the

understanding by the workforce about the organisation functioning in a digital context [1][21]. Cultural change will underpin the sustainability of the impact generated by digital transformation. A digital organisational culture will provide

employees with the right structures, incentives and mindsets to integrate new technologies into their work. Finally, the process of supply chain transformation requires a baseline understanding of the current operational model.

Understanding the current state of the organisation through a value stream mapping exercise is essential to identify the key components of the supply chain, critical activities vulnerable to disruptions and the full order-to-fulfilment process. It is also important to consider what the right KPIs are in order to understand whether a digital initiative delivers what is expected [21].

IV. CONCLUSION

Digital transitioning can improve an organisation's performance by engendering change through a combination of information, computing, communication, and connectivity technologies [1][21]. The complexity and challenges should not be underestimated but if adopted allow for the creation of new value propositions, and a better understanding of how systems are used. Underpinning such an approach does however require an holistic strategic approach which moves towards connected digital approaches. Research suggests that leadership, capability building, empowering workers, upgrading tools, and communication are likely to become key areas of value, and hence for research. Digital platforms have made major advances in advancing the operational efficiency of logistics, cost management and competitive advantage. However, there are areas where considerable improvements could be made, e.g., in workforce management, human behavioural inputs and the balance between commercial and intangible measures of performance.

Rapid and fundamental change in the sector is required in order to address the inefficiencies of existing systems that underutilise transport capacity and are confronted by delays and congestion. The developments in ICT, and digitalisation outlined in this paper will go some way to addressing the shortfalls in the existing systems. There are significant competitive and sustainability advantages to be gained as these new technologies are leveraged and exploited more widely. These will transform transport, logistics and supply chain management bringing benefits including higher service speeds, greater reliability, lower operating costs, and improved efficiency.

However, while opportunities exist, many organisations have not yet developed ICT capability to meet current challenges, redefined relationships and strategic change to effectively respond to customer requirements. Rapid adaptation to changes in competitive commercial environments is a recognised problem and fundamental to the success or otherwise of many businesses. Thus, the sharing of data between logistics companies and shippers, combined with advances in ICT to ensure information flows are integrated between logistics partners and supply chains members, will provide the best conditions for organisations to remain competitive. It is important for logistics and supply chain

organisations to first understand the strategic value of ICT for the management of their supply chains and logistics networks, and then to assess what the impact on business performance could be. Therefore, organisations utilising ICT will need to develop sophisticated systems that enhance business performance and create value. Digital capabilities will need to be fit for the information processing needs of the key stakeholders involved.

Organisations that adapt their business models and adopt ICT systems effectively are likely to be more successful and leveraging such systems will lead to greater competitive advantage, reshaped supply chains, improved service speeds and reliability, lower operating costs and improvements in efficiency. Positive adaptation to change will be fundamental to success and it will be important for supply chain organisations to understand the strategic value of ICT and assess what the impact on performance might be. Any organisation preparing to adopt a digital transformation strategy will need to set this in the context of a robust business model. The three areas of data and technology, people and process suggested earlier could be utilised to make sure a systematic approach is in place which helps to identify gaps in current capabilities [1][21]. However, this research suggests that there are particular areas where considerable improvements could be made, e.g., in workforce management, human behavioural inputs and the balance between commercial and intangible measures of performance.

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