

## CHAPTER 1

# Falling Behind or Riding the Waves? Building Future Supply Chains with Emerging Technologies

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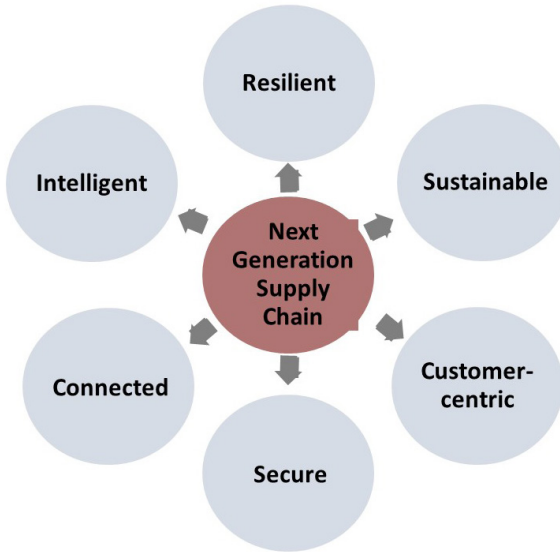
### An Outlook on the Next-Generation Supply Chain

Supply chains are constantly evolving and increasingly intertwined with the development of digital technologies. As observed by Gartner, a tremendous wave of automation and augmentation has sped through corporate supply chains in the last few years (Youssef, Titze & Schram 2019). With rapidly evolving customer demands and the emergence of new business models, organisations need to leverage these new business concepts and technologies to build new capabilities and future-proof their supply chains in order to remain competitive in the marketplace. So, what would a future supply chain look like? Figure 1.1 highlights the key attributes of a future supply chain – and each of these attributes is discussed in the following sections.

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**Figure 1.1:** The key attributes of the next-generation supply chain. Source: Authors.

### Resilient Supply Chains

Supply chains operate in a volatile world with increasing uncertainties and disruptions. These disruptions include, for instance, changing customer demand, competitors' activities, unforeseen incidents, geopolitical movements (such as the US–China trade war and Brexit), natural disasters and the current Covid-19 pandemic. Conversely, it should be noted that supply chain disruptions can also bring unexpected opportunities for success (Sheffi 2005). As has been witnessed, e-commerce fulfilment has seen significant growth during the pandemic. Nonetheless, disruptions force companies to reassess their supply chain strategies, network structures and footprints. Thus, it is of paramount importance that the next generation of supply chain be *resilient*, namely, to be able to sense, respond to and recover from disruptions by maintaining continuity of operations at the desired, or with an even better, level of connectedness and control (Ponomarov & Holcomb 2009; Tukamuhabwa et al. 2015).

A key competence or capability for supply chain resilience is agility – the ability to rapidly respond to unpredictable and constantly changing conditions. Swafford, Ghosh and Murthy (2008) argued that agility is a core competence that relies on various capabilities, specifically various forms of flexibility. They further pointed out that information technology (IT) is a key enabler to flexibility, which in turn results in higher supply chain agility. In fact, IT itself needs to be flexible in order to support effective supply chain responsiveness

and performance (Han, Wang & Naim 2017). As supply chains strive to adapt to a fast-changing world, technology can play a major role in making them more agile, responsive and efficient. For example, by utilising big data analytics and machine learning, organisations could develop advanced demand sensing models that incorporate both structured and unstructured data from a variety range of sources, adding a new level of granularity and accuracy to demand forecasts. IT is also essential to building supply chain visibility. By utilising established (e.g. radio frequency identification (RFID), global positioning system (GPS) and cloud computing) and emerging technologies (e.g. digital twin and blockchain), organisations can build real-time or near-real-time visibility into their supply chain. This ability to 'see' what is happening in the supply chain across organisational boundaries improves firms' adaptability and enables them to reconfigure their supply chain resources for greater competitive advantage (Dubey et al. 2018; Wei and Wang 2010).

### Sustainable Supply Chains

Nothing is more pertinent than embedding sustainability in supply chain operations. Future supply chains must incorporate not only economic but also social and environmental goals in their strategies and practices, deploying the so-called 'triple bottom line' (Elkington 1998). At the centre of the concept of the triple bottom line lies the idea that a sustainable organisation is one that creates profit for its stakeholders while protecting the environment and improving the lives of those with whom it interacts (Savitz 2013). The year 2020 marks the fifth anniversary of the adoption of the Sustainable Development Goals by the United Nations. These goals are the blueprint to achieving a better and more sustainable future for all, and therefore should be the guiding framework for all types of supply chains actors. They address the global challenges we face, including poverty, inequality, climate change, environmental degradation, peace and justice (United Nations 2020).

The growing trend of more destructive climate disasters such as the Australian bushfires and South Asian floods demonstrate all too well the urgent need for action on climate change and global warming (BBC 2020; ReliefWeb 2020). Scientists have pointed out that holding warming to 1.5°C above pre-industrial levels could limit the most dangerous and irreversible effects of climate change (IPCC 2018). This means that every part of the global economy needs to rapidly decarbonise. Climate change is already having substantial physical impacts in regions across the world, for instance severely paralysed critical transport infrastructures, which impacts on the movement of goods. Future supply chains need to adapt and adopt lower carbon strategies with conscious decisions made about their carbon footprints. This requires strategies that use more renewable resources and eliminate waste from end-to-end supply chains. They will also need to have embedded in them the principles of the circular economy, which

advocates for the change from a linear ‘take–make–use–dispose’ consumption model to a circular one. This principle aims to keep resources in use for as long as possible, extract the maximum value from them while in use, then recover and regenerate products and materials at the end of each service life (WRAP 2020).

One notable concept, albeit one that is still in its infancy, is the idea of a ‘material passport’, based on the idea of the circular economy and powered by blockchain technology (Heinrich & Lang 2020). A circular supply chain underpinned by blockchain technology provides a material backbone that offers a comprehensive and trustworthy record of material composition and value throughout its life cycle. The interconnectivity and visibility at a supply chain ecosystem level will lay the foundation for the better tracking of material flows and the rates of cyclical use, reduction and disposal, and the effective set-up of a closed-loop supply chain. This will allow various sectors (for example, construction, automotive and electricals) to go beyond improving energy efficiency, transforming both asset utilisation and materials management within these sectors.

In recent years, burgeoning issues related to social sustainability have also been gaining in importance (Mani et al. 2016; Sarkis, Helms & Hervani 2010). Hutchins and Sutherland (2008) recommended several proposed measures of social sustainability for supply chain decision-making (labour equity, healthcare, safety and philanthropy) that serve as a starting point to establish a comprehensive social footprint for a company. Again, digital technology is seen as a critical enabler in areas such as using internet of things (IoT) devices for tracking and estimating possible dangers, thus increasing workplace safety.

### Customer-Centric Supply Chains

Supply chain functions within organisations have shifted from inward-focused supply management to supply chains that orchestrate a profitable response to demand. Traditional customer segment and customer service management have evolved to focus on ‘micro-segmentation’ and ‘personalisation’ – tailoring products and services to individual customers’ needs at *scale*. Personalisation at scale requires companies to build their agility and flexibility, supported by underlying digital capabilities. For example, with its direct-to-consumer online model, Nike allows its customers to customise their shoes based on a range of design options, achieving economies of scale and scope at the same time.

Speed in response to customer demand is also key to customer satisfaction, and it is of particular importance in business to consumer (B2C) industries. Customers want a seamless online and offline experience and demand a very short order to delivery time (for example, same-day delivery). JD.com is able to utilise its digital platform, fully automated fulfilment centre and advanced demand sensing capability to offer a same-day or next-day delivery service to

90% of its orders in China, and holds a four-minute order fulfilment record that is unlikely to be outperformed anytime soon by its e-commerce competitors (Bowden 2018).

As customers will only continue to value more personalised services and products, the demand on future supply chains to meet their expectations will only increase. To successfully ride this wave of change, companies need to continuously evaluate how digital disruption is changing customer behaviour, rethink their customer engagement model to leverage disruptive technologies, and proactively orchestrate a customer journey that goes beyond selling and maximising the value offering across the life cycle from product design to sale, use and end of life. Sharma, Gill and Kwan (2019) argued that equally important for business to business (B2B) companies is the capability to leverage the proliferation of enterprise internet of things (IoT), anything-as-a-service (XaaS) solutions and cloud computing to build outcome-focused customer success management – especially establishing a customer-centric digital transformation to help increase ‘stickiness’ and customer loyalty. They further argued that future customer touchpoints will increasingly be skewed toward digital, providing a real-time customer experience that is contextualised, personalised, and driven by data and usage.

### Intelligent Supply Chains

Future supply chains should be *intelligent*, in that they can sense, act and adapt autonomously without much human intervention. This may sound quite far-fetched but, after six decades of development, artificial intelligence (AI) has reached a tipping point (Wang, Skeete & Owusu 2020). As discussed later, there are a number of use cases in supply chains that could benefit greatly from AI. AI started from automating mundane and repetitive tasks back in the 1960s, and has now developed to being able to predict and prescribe intelligent recommendations for action, thanks to the latest developments in machine learning, increasing computing power (graphics processing unit) and the availability of big data. We will increasingly see our decisions being augmented by machine learning algorithms, human operators working alongside robots on production lines and fulfilment centres, autonomous vehicles such as truck platooning, drones for delivery, and the use of chatbots for customer services.

The latest McKinsey global survey (2020) of over 2,300 participants on the state of AI identified that, in supply chains, efforts have been concentrated on two areas: logistics network optimisation, and inventory and parts optimisation. For manufacturing, this has been in areas of yield, energy and/or throughput optimisation and predictive maintenance. Within these functions, the largest share of respondents reported revenue increases for inventory and parts optimisation, pricing and promotion, customer service analytics, and sales and demand forecasting. Over half of the respondents said that use cases on

cost reduction are mostly from the optimisation of talent management, contact centre automation, and warehouse automation. Revenue increases from AI adoption in that year were more commonly reported in half of business functions, but cost decreases were less common. The survey also revealed that the adoption of deep learning (a subset of machine learning that uses artificial neural networks to analyse unstructured data inputs such as images, video and speech) was mostly at an early stage, with only 16% of respondents saying they had taken deep learning beyond the pilot stage. However, AI will be the power engine behind autonomous vehicles, robotics and a number of other use case areas in the near future. High-tech and telecom companies are 'leading the charge'. Organisations need to watch these developments closely, otherwise they may risk being left behind.

### Connected and Secure Supply Chains

The foundation of resilient, sustainable, intelligent and customer-centric supply chains is supply chain connectivity and end-to-end visibility. This is best envisaged as data and information flowing through the supply chain network like water flows in a pipeline. In a fragmented supply chain, the flow tends to be interrupted frequently due to a number of barriers such as organisational silos and a lack of interoperability between IT systems. A fragmented supply chain often has a longer cycle time and is less responsive to customer needs and business disruptions. On the other hand, a highly connected supply chain allows data to flow smoothly between different functions within an organisation and between organisations. Connectivity, plus the willingness to allow information sharing, leads to much-needed supply chain visibility, which is critical for supply chain planning, execution and analytics. In an ideal state, there would be a supply chain digital twin in place, that is, a digital representation of real-world physical supply chains, including all relevant ecosystem actors (suppliers, customers, service providers and others). A digital twin allows clear visibility into complex, interconnected supply chains, and performs both optimisation of coordination for the current state and what-if analyses for the future state.

However, what supply chain executives and academia tend to forget is that a digitally connected supply chain also needs to be highly secured. Cybercrime leads to data breaches, financial crimes, market manipulation and the theft of personal data, and poses risks to public safety and security. According to a National Crime Agency report (National Crime Agency (NCA) 2017), within three months of the creation of the National Cyber Security Centre (NCSC) in June 2017, the UK was hit by 188 high-level attacks that were serious enough to warrant NCSC involvement, and countless lower-level ones, indicating that cybercrime is increasingly aggressive and frequent. The vulnerability of supply chain systems was clearly illustrated by the recent case of the NotPetya

cyberattack on a number of organisations, including the world's largest container shipping line, Moller-Maersk, in June 2017. The attack affected all its business units' operations and resulted in \$300 million of lost revenue (Milne 2017). The rising number of IoT devices increases security risks to supply chains because many connected devices have less secure software and are vulnerable to malware. Millions of insecure IoT devices are connected to the internet and have become the 'botnet of things', presenting 'a serious challenge to cyber security for a considerable time to come' (NCA 2017: 8). Therefore, all supply chain actors in the ecosystem should make cyber security a top priority. The UK's National Cyber Security Centre provides excellent guidance and principles on supply chain security to help organisations establish effective control and oversight of their supply chains (NCSC 2020).

## Emerging Technologies and Their Impact on Supply Chains

Supply chains are experiencing the implementation of a new wave of digital technologies, ranging from AI, the IoT, digital twins, 5G, big data and advanced analytics to blockchain/distributed ledger technology. Such technological developments affect *every* industry, create disruptions, and bring profound changes to the way supply chains are configured and managed. It is widely recognised that organisations need to leverage these emerging technologies and future-proof their supply chains by transforming into digital supply chains or, in a wider sense, digital supply chain ecosystems (Garay-Rondero et al. 2020; Nasiri et al. 2020). A brief examination of some of these technological developments is now provided.

### Cloud Computing

At the infrastructure level, it can be seen that the deployment of cloud computing has been adopted as for mainstream use. Using a network of remote servers hosted on the internet to store, manage and process data, cloud computing allows third parties to host ICT systems on behalf of their customers. This provides flexibility and ease of use to enable not only large companies but also small and medium-sized enterprises (SME) to adopt such systems, significantly reducing entry barriers for them and fuelling new business models pioneered by technology service providers (TSP). For example, the use of telematics and GPS for tracking tractors and trailers is well established in road freight. On-demand models promoted by TSPs allow haulage companies to lease rather than buy tracking devices, representing a significant saving on fixed assets. From infrastructure as a service (IaaS) and software as a service (SaaS) to platform as a service (PaaS), cloud computing offers a flexible technology solution for organisations, providing scalability when required. The use of cloud

computing is also expected to increase with the enhanced connectivity offered by full fibre and 5G.

Cloud computing, compared with other technologies, is probably the most established technology in supply chains. The most frequently mentioned impact of cloud computing is affordability, and specifically cost savings, in terms of capital expenditure, labour costs and power and cooling costs (Leimbach et al. 2014). For SMEs, cloud computing offers a high level of security when there is a lack of in-house expertise. Cloud computing also gives organisations the flexibility to scale up or down quickly, allowing businesses to experiment and launch new services and products much more quickly. This may lead to the emergence of new start-ups and potentially new job opportunities.

### Pervasive Computing and the IoT

As computing power increases, and smart devices become smaller, more affordable and capable, people and devices will become more connected than ever before. Such ubiquitous connectivity and network services enable real-time visibility across supply chains, which is critical for dealing with rising uncertainty and complexity in freight transport, especially in multimodal environments. A key enabler for such technological development is pervasive computing (Satyanarayanan 2001). The most prevalent forms of pervasive computing include ubiquitous computing,<sup>1</sup> ambient intelligence,<sup>2</sup> sentient computing<sup>3</sup> and the IoT. While each form has a slightly different focus, in practice all of these augment everyday objects with microelectronic sensors and actuators, and wireless communication capabilities (Bibri & Krogstie 2017). Hence, they become ‘smart’ objects, they ‘know’ where they are, which other things are in the locality (context awareness) and what happened to them in the past.

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<sup>1</sup> Ubiquitous computing is a concept in software engineering and computer science where computing is made to appear everywhere and anywhere. Computers will function invisibly and unobtrusively in the background, and make everyday objects smart by enabling them to communicate with each other, interact with people and their objects, and explore their environment, thus helping people to carry out activities or tasks whenever and wherever needed.

<sup>2</sup> Ambient intelligence (AmI) refers to the presence of a digital environment that is sensitive, adaptive and responsive to the presence of people. This is the term preferred by the European Union.

<sup>3</sup> Sentient computing denotes the use of sensing devices to observe and monitor and computing devices to perceive (recognise and interpret) and react to the physical environment.



Currently, the IoT's main deployment in supply chains lies in product tracking and monitoring, for example inventory management and control in the supply chain, real-time routing, dynamic vehicle scheduling, management of trailers, containers and other heavy assets, and shipment tracking. Railway tracks, autonomous vehicles (AVs) and flight navigation can derive further value from IoT (Manyika et al. 2015). In sectors actively exploring the use of the IoT, RFID is the most widely used smart object in supply chains. RFID tags contain embedded microchips that allow freight operators to track individual assets and containers and to determine the temperature and humidity of frozen or liquid goods or a vehicle's mechanical condition. One example of innovative IoT use is that of the German carmaker Daimler, which launched the car2go service, using IoT functionality to monitor and manage cars remotely, allowing customers to use shared cars as required. This represents a radical change in Daimler's business model, transforming it from a car manufacturer to a mobility service provider. Retailers are also at the frontier of IoT adoption. Sensors already automatically check out customers purchases and restock the retail inventory after purchase. RFID tags track inventory throughout the store, shelf sensors ensure the inventory is on display, and mobile payments reduce checkout queues.

The concept of the digital twin is closely related to the IoT. A digital twin is a virtual doppelganger of a real-world object, or a complex ecosystem of connected objects, such as an AV in the middle of rush-hour traffic. Engineers can analyse how a vehicle performs not just in its physical environment but over its entire life cycle. Digital twins are particularly valuable in the telecommunications, transport and construction sectors, where the management of an asset's life cycle is critical to its correct functioning. The IoT, simulation software, and machine learning and predictive analytics systems are three emerging technologies that enable digital twins. Although many people still interface with digital technologies via keyboards, screens etc., interfaces will not be needed in the future. Instead, we will interact with them, thanks to the instantaneous two-way communication enabled by the IoT.

## Artificial Intelligence

As intelligent algorithms become more sophisticated and computing power grows significantly, machines have started to gain human-like cognition, enabling them to, for instance, drive trucks, aeroplanes or trains, and this led to the concept of artificial intelligence (AI). Robotics and AVs, computer vision, language, virtual agents and machine learning are the key developments of this technology (Bughin et al. 2017; Hall & Pesenti 2017). High-tech and financial services are the leading sectors for AI deployment. The automotive and assembly sectors were some of the first to implement advanced robotics for manufacturing and developing self-driving cars. Retailers rely on AI-powered robots

to run their warehouses, automatically ordering stock when inventories run low, and even running unmanned stores. With smartphone penetration, retailers have developed omni-channel sales strategies, which AI can help optimise, update and use to tailor sales to each shopper in real time.

Clearly, manufacturing and financial services are leading the use of AI. For manufacturers, AI is deployed to automate assembly lines, predict sales of maintenance service, and optimise route and fleet allocation for logistics activities. Transportation and logistics demonstrate a reasonable scale of AI adoption. This reflects the substantial progress made towards truck automation and platooning in recent years.<sup>4</sup> Truck automation requires AI to process the vast amounts of data collected by a vehicle's sensors. For example, truck automation requires spatial recognition and an understanding of the vehicle's immediate environment as well as its exact location. Limited self-driving automation requires the ability to anticipate the behaviour of other vehicles, pedestrians and animals while simultaneously considering the movement of the vehicle. Although there have been significant developments in AI, these capabilities are not fully developed (Eastwood 2017).

Another area of AI application is in robotics and warehouse automation. Articulated robots have been seen for many years in warehouses assembling pallet loads from trailers and containers. The use of next-generation robotics for online e-commerce (EC) order fulfilment is one of the new areas for further diffusion. EC orders are usually small, often requiring only one or two items to be picked up at a time. Current industrial practice of order-picking is largely manual, hence large EC fulfilment centres tend to employ hundreds of pickers and packers in order to achieve their delivery targets, particularly during peak seasons such as Christmas and Black Friday. Many have an ambitious target of 15 minutes from click to ship, which is only achievable with the use of robots (Cooper 2018). Some believe that finding labour will be more challenging following the UK's exit from the EU. This makes a more compelling case for the adoption of robotic picking. Large logistics companies such as DHL have piloted the use of autonomous robotic cobots for picking.<sup>5</sup> Amazon is also a pioneer in robotics, spending \$775 million in 2013 to buy a start-up, Kiva, a company that builds mobile robots. These robots can pick up a shelf of goods

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<sup>4</sup> 'Platooning' refers to several freight vehicles that are travelling autonomously in convoy and in communication with each other. It involves a lead truck whose human driver navigates traffic, with several trailing vehicles automatically undertaking the steering and braking required to maintain a safe (mostly fixed) distance from the vehicle in front. This concept is currently being trialled in Europe, and has the potential to increase the volume of freight traffic (SMMT 2020).

<sup>5</sup> 'Cobots' are collaborative robots that work side by side with human employees, supporting repetitive and physically demanding tasks in logistics.

and bring the entire shelf to the picker, who can stay in one spot to assemble the order, eliminating the need for excessive walking between aisles in a warehouse. This concept is known as ‘goods-to-picker’ and in some cases has led to a 50% saving in warehouse picking labour (DHL 2020).

In addition to warehouse automation, the use of AI in retailing could anticipate demand trends, optimise product assortment and pricing, personalise promotions, offer immediate assistance with virtual agents, automate in-store checkouts and complete last-mile delivery by drones. In the context of virtual assistants, the concept of ‘conversational technology’ emerges, powered by rich visual interfaces and AI (Mimoun & Poncin 2015). Apart from its application in education and smart homes, conversational technology has emerged in customer service (via messaging apps), allowing a continuous customer–brand conversation. These app-based, AI-driven conversations enable the brand to zoom in on what customers need, regardless of how they say it, based on an understanding of context. Such conversational technologies may diffuse into logistic areas such as warehouse picking and vehicle loading, where operators receive specific guidance and advice in real time to complete their tasks. It may be useful for simulated training and learning as well.

Although automation and AI will improve productivity and economic growth, they are not without concerns, such as the potential effects on employment. According to a recent McKinsey report, 60% of occupations have at least 30% of work activities that could be automated (Manyika et al. 2017). Even so, even with automation the demand for work and workers could increase as economies grow, partly fuelled by productivity growth enabled by technological progress. During this transition, the workforce needs to be reskilled to exploit AI, rather than compete with it, and governments with ambitious AI strategies will need to join the global competition to attract AI talent and investment. Autonomous robots powered by AI may also threaten human identity, uniqueness, safety and resources, and hence progress is required on the ethical, legal and regulatory challenges that could potentially inhibit AI. Companies also need to adapt to different ways of working, whether in integrating AI or with on-demand workers.

## **Immersive Technologies**

Immersive technologies blur the boundary between the physical and the digital (or simulated) world to create a sense of immersion. Related terms include virtual reality (VR), augmented reality (AR) and mixed reality (MR). Such technologies provide a stimulating, multimedia digital environment for people to experience, rather than just read, watch or listen. Given that the boundaries between products, services and environments have blurred, immersive technologies are increasingly applied in practice. Currently, there is strong demand for immersive technologies from industries in the creative economy – specifically,

gaming, live events, video entertainment and retail (Hall & Takahashi 2017) – but wider applications are found in the manufacturing and maintenance, tourism, healthcare, education, transport and construction industries. For example, in construction, Costain UK applied AR to its construction project at Custom House station in east London, allowing its customer Crossrail to view the planned construction works in a 3D image overlaid onto a view of the real site with an iPad (Cousins 2014).

There are subtle differences between VR, AR and MR. AR is by far the most deployed term both academically and in practice. There are limited studies on the impact of immersive technologies specifically in the logistics sector, but obvious areas of application include on-the-job training, real-time process instruction, navigation and wayfinding aids, and digital interaction with customers and partners. Cirulis and Ginters (2013) pointed out that AR could significantly improve some logistics operations, including order-picking in a warehouse using path-finding techniques. Integrated with existing technologies such as voice-picking, this could improve the productivity of the workforce and radically change the way employees perform tasks.

One example of a picking system using AR technology is KiSoft, which displays information regarding location through a head-mounted display (KNAPP 2013). The purported advantages include visual, error-free picking instructions with fully automated goods and serial-number tracking, adaptable to every warehouse without any structural changes. In the retail sector, Tesco has begun augmented technology trials, where web cameras and mobile devices view life-size projections of products before purchase. Immerseuk.org have illustrated how immersive technologies have trained ground operation crew in the aviation industry, demonstrating the value of AR for training when the real environment is potentially dangerous or noisy, or when employees are unable to experience real-life situations or learn on site. Another example is Unilever's use of collaborative robots and VR simulators to automate repetitive manual tasks and improve the safety, operation and maintenance of equipment. Its technicians use AR glasses to record and share best practice in maintenance procedures across the network (Aronow, Ennis & Romano 2017).

## Distributed Ledger Technology (DLT)

Widely considered one of the most disruptive technologies, DLT (also known as blockchain technology) enables the creation of decentralised currencies such as Bitcoin, self-executing digital contracts ('smart contracts') and intelligent assets that can be controlled over the internet (Wang, Han & Beynon-Davies 2019). DLT can be perceived as another application layer that runs on top of internet protocols that enable economic transactions between relevant parties. It can also be used as a registry and inventory system for recording, tracing, monitoring and transacting assets (whether tangible, intangible or digital). From a

business perspective, a blockchain is a platform whereby values are exchanged among peers without requiring any trusted third party.

There are two main types of distributed ledgers, based on access control mechanisms, regarding who can read a ledger, submit transactions to it and participate in the consensus process:

1. Public ledger: every transaction is public (permissionless) and users can remain anonymous. The network typically has an incentivising mechanism to encourage more participants to join the network. Bitcoin and Ethereum are examples.
2. Permissioned ledger: participants need to obtain an invitation or permission to join. Access is controlled by a consortium of members or by a single organisation. These are a viable option for the freight ecosystem.

Earlier versions of blockchain are permissionless: transactions are broadcast to every single participant (node) and every node thus keeps a complete record of the entire transaction history. Economic incentives are built in to encourage honest behaviour, e.g. rewarding miners with tokens. Bitcoin is a typical example of a permissionless blockchain. Later, organisations realised that, owing to the sensitive nature of their data and regulatory concerns, sometimes a public blockchain was not a feasible option. As a result, permissioned (also known as private) blockchains (where only authorised participants can join) emerged to adapt to the needs of those organisations. Most blockchain technology networks observed so far in logistics and supply chains have been permission-based – where transactions and transaction-related data are only broadcast to selected parties (those involved in a specific trade to which these transactions relate).

Typical use cases of blockchain in supply chains include:

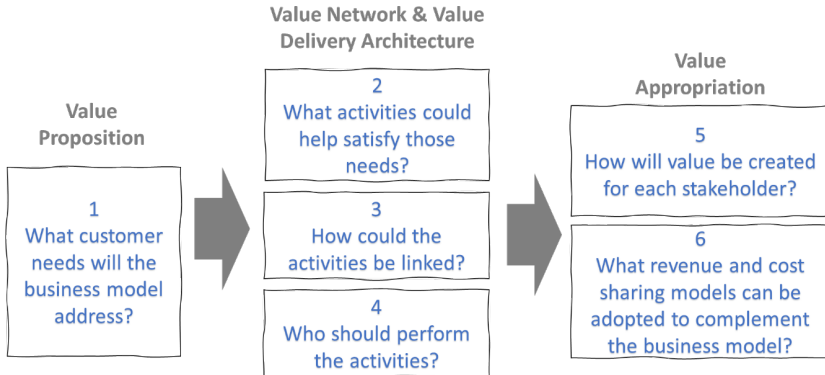
1. Product provenance and traceability: a blockchain system offers extended visibility among multiple supply chain actors of a (digitised) product's digital footprint, from manufacturing to distribution and sale, thus creating the so-called 'see-through' supply chains. The immutability afforded by a blockchain system enhances data integrity and leads to increased confidence from customers of products' legitimacy. Moreover, the use of timestamping (the process of providing a temporal order among sets of events) in the blockchain can prove the existence of certain data at a point of time, avoiding potential conflicts and disputes between parties over time-sensitive issues. Information completeness can be enhanced as well, as blockchain can accommodate a wide range of data, including ownership, location, product specification and cost.
2. Process and operation improvement: a blockchain platform can help to ease the current heavy workload on information transfer and processing, and bring multiple stakeholders together by the digitalisation of docu-

ment transfers and the acceleration of the flow of data. A typical example often cited in the literature is IBM's cross-border platform enabled by blockchain.

3. Automation and smart contracts. Current operations, processes and data exchanges in logistics and supply chains are often manual, slow and error-prone. With smart contracts, blockchain technology allows for increased automation and efficiency through avoiding the rekeying of data, speeding up of transactions and reduction of errors. In the blockchain context, smart contract is a computer code running on top of a blockchain containing a set of rules under which the parties to that smart contract agree to interact with each other. If and when the predefined rules are met, the agreement is automatically enforced. The smart contract code facilitates, verifies and enforces the negotiation or performance of an agreement or transaction.
4. Trade finance and settlement: blockchain used in trade finance mainly focuses on removing inefficiencies from existing processes. For example, blockchain can be used for faster credit risk assessment, minimising human errors in documentation checks, instant verification and reconciliation of records, automatic execution of workflow steps via smart contracts, and instant and secure exchange of data.
5. Anticorruption and humanitarian logistics: in a blockchain, unethical or opportunistic behaviours are made visible to all participants. This level of transparency can be of great value to traditional supply chains, such as in pharmaceuticals, where dominant supply chain actors may manipulate the market to inflate product prices, or in coffee supply chains, where a fairer payment to farmers can be made visible to relevant stakeholders. Similarly, a blockchain system could help to expose and eliminate corruptions that are witnessed in certain public–private interactions. In a similar vein, blockchain has been deployed in humanitarian supply chains to ensure that financial or other emergency aid reaches the target beneficiaries.

### Supply Chain Digital Transformation

Supply chains are inherently complex and difficult to transform. Achieving a completely smooth operation and building the next-generation supply chain with the aforementioned attributes is incredibly hard but not impossible. Figure 1.2 attempts to offer a structured way for supply chain digital transformation based on the concept of business model (Wang, Chen & Zghari-Sales 2020). A starting point should be to re-examine the business value proposition – again, to have a customer-centric mindset. No matter which value proposition an organisation uses to become a digital supply chain, it will create an impact and cause changes in strategy and other parts of the business and operating models. For supply chain practitioners, this often starts by asking what



**Figure 1.2:** Supply chain digital transformation value framework. Source: Authors.

the pain points in the current supply chain are or whether there is an unmet (or poorly met) demand.

Once a value proposition is developed, one should move to examine how supply chains should be configured in a way that multiple supply chain actors are interconnected to coordinate and collaborate to deliver the proposed value. This is to do with process and information flow orchestration. Value network and delivery architecture are concerned with a bundle of specific activities conducted to satisfy the perceived needs of the market, along with the specification of which parties (a company or its partners) conduct which activities, and how these activities are linked to each other. Lastly, there is a need to craft a revenue mechanism and to appropriately decide and agree upon cost and benefit sharing. This is extremely important as most supply chain digital initiatives will have to involve different supply chain actors. If the investment is heavily skewed towards a particular group of supply chain actors and benefits are not distributed fairly, there is a great danger that the consortium network would collapse.

## Structure and Chapters

In the context of the many challenges outlined above, the consistent and common theme running throughout is the rapid rate of change occurring. There is no doubt that existing ways of working, which have already been impacted in many ways, will continue to change rapidly over the next decade. The rate of change now, compared to even at the turn of the 21st century, means that many activities are conducted in substantially different, and in some cases almost unrecognisable, ways. Such changes will allow many companies to thrive and increase in size: witness, for example, the growth of companies such as

Amazon, which, from starting in 1994 selling books, is now a global company dominating online sales in multiple retail areas. Similarly, although at a smaller scale, grocery retailers such as Ocado have entered the market and utilised technology to disrupt the existing model of sales. Amazon and Ocado, among many other digitally driven companies, are beginning to render the long-established high street sales model redundant. Such companies are impacting how supply chains operate and, throughout the chapters that follow, we present examples of key areas where digital innovation is a necessary consideration for effective logistics practices, and where systems may already be embedded in supply chain activities.

In Chapter 2, Jeong Hugh Han considers how supply chains can be made more efficient in order to achieve the objective of maximising the stakeholders' economic profitability, while meeting the diverse range of customer requirements. The underlying discussion pertains to the role of emergent blockchain technology, which is beginning to influence how firms and IT service suppliers improve supply chain agility and flexibility using blockchain. He goes on to discuss the role of blockchain in global supply chain management and cross-border trade and explores the future of supply chains underpinned by blockchain.

Chapter 3 considers how AI can be used to optimise assets and inventory. Sid Shakya, Anne Liret and Gilbert Owusu look at how a business such as BT deals with the key resources that service organisations such as telecommunications companies maintain, that is, their assets and inventories. In the discussion they address both strategic and operational dimensions of the deployment challenge for such companies. From a strategic perspective, there is a need to deploy fixed assets for optimal performance, while at the same time from an operational perspective there is a need to replenish inventory to be able to deliver services in line with customer service level agreements. This creates a 'combinatorial optimisation problem', which it is suggested makes AI a useful technology for solving such problems for operational use.

Frank Omare demystifies digitalisation and illustrates the benefits it can bring to supply chains. In Chapter 4 he provides insights into the focus and outcomes of digitalisation and how digital failure might be avoided. As supply chains have become more complex, increased risk has been created, along with a constant pressure to monitor every aspect of the extended supply chain ecosystem. Digitalisation plays a key role in addressing visibility and transparency issues across the supply chain and helps to improve collaboration between supply chain partners to create more effective supply chains. While, for many organisations, digital transformation is a strategic imperative – improving connectivity and increasing access to, and distribution of, critical data – many organisations fail to re-engineer their business processes and dedicate insufficient resources to deploy such technology effectively.

In Chapter 5, Andy Lahy, Katy Huckle, Jon Sleeman and Mike Wilson discuss the reasons why the current 'contract logistics model' is not suitable for today's



fast-moving, adaptive supply chains. The context for the chapter is how the contract logistics industry currently works, before a new model, referred to as E-Space, is introduced. The model is an attempt to redraw the existing 'contract logistics model' and implement flexible, fast and agile supply chains that can free up manufacturers and retailers to meet the short lead times consumers demand. In doing so, the model is designed to re-engineer the supply chain rather than the current contract logistics approach, which generally, in simple terms, is not adaptable. Thus, in order to meet consumer demand, supply chains have not completely changed but rather more inventory has been added in more warehouses, resulting in an 'explosion of inventory across supply chains,' with products sitting in warehouses, costing money and losing value.

In Chapter 6, Takis Katsoulas, Ioanna Fergadiotou and Pat O'Sullivan look at how the European Union is developing an approach to address the substantial change taking place in the transport and logistics sector, influenced by factors such as globalisation, smart specialisation, population growth, business competition, and consumer interest for globally sourced products. The European Commission's strategy for Smart, Green and Integrated Transport and Logistics identified the need for a common communication and navigation platform for pan-European logistics. In parallel, a central goal of the Commission was to boost competitiveness in the European transport and logistics sector and develop a resource-efficient and environmentally friendly European transport system. Central to the EC's strategic vision was the development of architectures and open systems for information sharing and valorisation to connect key stakeholders on the basis of trusted business agreements. The evolving landscape set the scene for creating innovative collaboration-driven supply chain optimisation and underpinned the innovation imperatives for the Shared European Logistics Intelligent Information Space (SELIS) project, which sought to address these issues and which is discussed in this chapter.

In the final chapter, 7, Yingli Wang and Stephen Pettit reflect on what digital transformation for the supply chain has meant, and what developments in the near future might mean. While such change is primarily focused at the organisational level, it can also be stimulated at industrial or societal levels, and in order to remain competitive an organisation will have to be responsive to such pressures. The improvements in performance and competitive behaviour generated by responding to digital advances and adopting new technologies allows organisations to both raise standards and lower costs. A range of other benefits including lower market entry barriers, the creation of new value propositions, and more effective targeting of the customer base have created a more competitive landscape, and a reduction in the advantages previously enjoyed by industry incumbents. However digital transformation is a complex process. While organisations adopting new technologies might be better equipped to sustain changes in the long term, lasting performance improvements critical for success require support through a range of management approaches.

In conclusion, the latest digital developments discussed can assist the supply chain community in gaining a more precise understanding of how a business can utilise those emerging technologies to build the supply chain of the future for competitive advantage. The chapters that follow outline recent technological and theoretical issues, and present the cutting-edge and latest thinking about how those digital technologies are disrupting the existing supply chain practices in a number of areas. Awareness of the critical role of digital technologies in supporting business operations as well as driving innovations in supply chains is important for both practitioners and academics. The chapters highlight the rapid changing digital landscape in supply chains and will give readers a better understanding of what needs to be done to embrace those digital innovations to future-proof supply chains.

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