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# Emerging Digitalisation Technologies in Freight Transport and Logistics: current trends and future directions

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## Abstract

This editorial piece discusses the current digitalisation trends and future research directions in freight transport and logistics. We characterise the current trends into three categories based on their transformative roles: connecting, collaborating, and capitalising. Under each category, we discuss the key technologies that are emerging and how they drive major changes in supply chain and logistics systems. We then introduce the special issue papers which address some of the topics under the proposed categories. The article ends with identifying the gaps in the literature and proposes a list of potential topics for future research.

**Keywords:** digitalisation, emerging trends, future research, freight transport and logistics, supply chain, emerging technology

## 1. Introduction

Freight transport and logistics (FTL) plays a critical role in seamlessly moving materials and finished products in supply chains. Like many other industries, the FTL sector is experiencing a new wave of digitalisation. Digitalisation refers to the use of digital technologies to support the existing and innovative provisions and management of freight transport and logistics. It often involves significant changes: 1) within organisations—such as change in business models and processes; 2) between organisations—such as governance, relational, technical and process configurations; and 3) at the level of ecosystem and industry—disruptions to the status quo and emergence of new product or service providers.

Technological advances such as artificial intelligence (AI) and machine learning, 5G, blockchain-distributed ledger technology, pervasive computing, data analytics, and immersive technology are developing at an unprecedented rate. These advances are transforming and disrupting the status quo of the FTL sector—having accelerated during the COVID-19 pandemic. Significant shifts in customers and consumer behaviours and expectations, facilitated by ubiquitous access to information, e-commerce and digital services, have reshaped the industry even further (Tipping and Kauschke 2016; Charm et al. 2020).

FTL digitalisation can influence many levels. It has great potential to contribute to organizational competitive advantage (Gunasekaran et al., 2017). Digitalisation can enhance transport sustainability with respect to physical, environmental, economic and social dimensions (Sarkis et al., 2020). Technological advances also enable seamless mobility

between different transport modes and a more integrated global freight transport ecosystem (Harris et al., 2015).

Digitalisation also leads to an emergence of new industry business models such as logistics-as-a-service including micro-fulfilment centers, and mobility-as-a-service (Kamargianni and Matyas, 2017; DHL 2020). These business models may also be supported through new financial models offered by digitalisation such as using cryptocurrencies and Internet of things (IOT). Socially, community redesign and the implication of smart cities and transport planning are also being influenced (Wang et al., 2016).

Yet, given all these forces and revolutionary technological advances, our scholarly and academic understanding of these disruptive emerging technologies remains fragmented and limited for FTL. The negative epistemic consequences resulting from the contemporary landscape of these digitalisation technologies is not well established. This special issue focuses on evolving research that seeks to explore the application and impact of emergent digitalisation technologies on the theory and practice of FTL.

## **2. Characterising current technological trends**

Gartner, known for its hype cycle research methodology for emerging technology, in its latest review (2020) outlines its top 8 supply chain technology trends—AI, edge computing and analytics, 5G networks, immersive experience technology, digital supply chain twins, and supply chain governance and security. In a similar vein, DHL—one of the largest logistics service providers in the world—published its 5<sup>th</sup> edition of the *Logistics Trend Radar* (2020) has also identified blockchain, cloud & application programming integration (API), autonomous vehicles and 3D printing as technology of impact that will transform future logistics management.

An extensive review commissioned by the UK government (Wang 2019) draws similar conclusions about these emerging technologies—with an additional emphasis on the importance of social media technology. Academic literature also concurs strongly with these views from practice concerning the impact of such emerging technologies (Büyüközkan and Göçer 2018; Winkelhaus and Grosse 2020). Together these technological developments are driving major changes in supply chain and logistics systems. The following subsections examine the transformative roles of such technologies in supporting FTL management from three aspects: connecting, collaborating and capitalising.

### **2.1 Connecting**

Fundamental to any digitalisation initiatives in FTL is the need to have appropriate information and communication technology (ICT) infrastructure for data capturing, storage, processing and sharing to build robust digital connectivity within and between organisations. The following technological advances are major developments in this area.

*Cloud computing*, initially known as utility computing or on-demand computing, has become mainstream after more than a decade's development. 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 (Armbrust et al. 2010). Cloud computing offers an elastic usage-based model which user organisations pay for just the cloud resources that they require. Its flexibility and ease significantly reduce entry barriers for small and medium sized

enterprises (SMEs) to use the system (Marston et al., 2011). For example, cloud-based internet platforms have been used by shippers for logistics and transport provisions which allow related organisations to ‘plug in and play’, rather than building costly dedicated electronic data interchange (EDI) links (Wang et al. 2011). Transport mobility solution providers, rather than selling telematics devices to fleet operators, would lease those devices and offer a cloud-based on-demand tracking services instead (Muynck and Duran 2019). From infrastructure as a service (IaaS) and software as a service (SaaS) to platform as a service (PaaS), cloud computing offers flexible technology for the FTL sector, allowing flexible scaling-up or down according to the needed capacity. Research on how cloud computing can contribute to the greening of logistics has also been put forward when considering more sustainable FTL (Subramanian et al., 2014). Deployment of cloud solutions is expected to increase with the enhanced connectivity offered by full fibre and 5G telecommunications technology.

5G, the 5<sup>th</sup> generation of mobile telecommunications technology, is another major technological advance. If fully incorporated, it will provide speeds up to 20 times faster than 4G (Gov.uk 2020). This technology has important implications for FTL operations. For instance, the increased connectivity and capacity afforded by 5G is essential to support innovative new services including autonomous vehicles and factory robotics. Initial pilots—such as Italy’s Port of Livorno using 5G for port operations--has demonstrated increased efficiency, reduced transit time of goods and reduced environmental impact of logistics operations (Ericsson 2020). 5G will underpin other advances in cutting-edge technologies such as virtual and augmented reality (VR/AR), which has seen use cases in the area of providing real-time, on-site, step-by-step visual guidance for production assembling and service operations, warehouse picking, as well as staff training on demand. VR/AR will become the new interface between human and machines, bridging the digital and physical worlds and changing how enterprises serve customers, train employees, design and create products and manage their value chains (Porter and Heppelmann 2017).

Driven by the explosive growth of IoT devices, *edge computing* is gaining momentum. Edge computing is part of a distributed computing typology in which information processing is located close to the edge – where things and people produce or consume that information (Gill and Smith 2018). IoTs are not new to the FLT sector. For example, RFID technology has been deployed for over two decades—for example by the consumer goods industry to track products and manage inventories. But historically data generated by RFID tags or other smart devices tend to be transmitted to a centralised cloud data center for processing. As the number of devices grow explosively the scale and volume of IoT data starts to cause bandwidth and latency issues and outpaced network and infrastructure capabilities (IBM 2021). Edge computing complements cloud computing by addressing the bandwidth and latency issues associated with cloud computing when processing massive amount of data and allowing computation to be performed at the edge of the network, on downstream data on behalf of cloud services and upstream data on behalf of IoT services (Shi et al. 2016).

As enterprises implement IoT projects, they may ultimately develop *digital twins*. A digital twin is a virtual representation of a real-world object, process or a complex ecosystem of connected objects, such as an autonomous vehicle driving in a traffic (Tao et al., 2019). Digital twins are designed initially to optimize the operation and reliability of assets or equipment and industrial efforts currently concentrate on critical assets and use digital twins to enable data-driven decision making (Lheureux, et al., 2020). Connectivity and visibility advancement

would be to establish a *digital supply chain twin* that mirrors a supply chain in practice. Research in this field is still at early stage but with promising results. For example, Ivanov and Dolgui (2020) develop a digital twin model for supply chain disruption management that represents the current state of the network and allows organisations to make use of data from the physical supply chain in real time. As an example IoT sensors and online risk databases can be used to test what-if scenarios and quantify the effects of changes.

## **2.2 Collaborating**

The integrative use of the aforementioned technologies builds fast, cost effective, and flexible digital connectivity, which in turn, supports organisations to achieve the much-needed end-to-end (E2E) real time supply chain visibility for better operations management and control (Somapa et al., 2018). E2E supply chain visibility goes beyond a focal organisation's boundary and extends to freight ecosystem partners – customers, suppliers, freight forwarders, logistics service providers, transport node operators as well as government agencies such as a customs agency. This activity requires some organisations to act as the freight ecosystem orchestrator that governs intercompany and intracompany collaboration. Within this context emerged the concept of *digital platforms* and *digital ecosystems*.

Digital platforms are not entirely new. Their earlier forms often known as electronic markets or marketplaces, later labelled as electronic networks, emerged after the Internet was commercialised in the late 1990s (Wang et al., 2007). Typically, those digital platforms operate as intermediaries to match supply with demand—for instance, Supplyon in the automotive industry and Elemica in the chemical industry. Later platforms evolved to support supply chain and logistics provisions such as order fulfilment (Grieger 2003; Wang et al., 2007). The broad term digital *ecosystem* often refers to an online community of interacting firms who coevolve their capabilities and roles and tend to align themselves with the directions set by one or more central companies (McIntyre and Srinivasan 2017).

FTL processes are increasingly handled by platform-based online systems that harvest data from different sources to ensure 'one version of truth'. This trend occurs across all four transport modes—land, air, water and rail—as evidenced by the concepts of single-window systems, electronic logistics marketplaces, port community systems and air-cargo ecosystems (Wang and Pettit 2016). Reasons for deploying platform-based systems include a desire to simplify the complexities of day-to-day transactions among cargo stakeholders, which include a number of players such as customs, forwarders, shippers, shipping lines, terminal operators, inspection agencies, hauliers and railway operators. Online platforms bring these stakeholders together, allowing them to communicate with each other seamlessly and enabling the re-use of data so that it only needs be entered into the system once. Prior to this technological development, communications were bilateral. The same information often had to be submitted multiple times to various parties, leading to errors, duplications and inefficiencies. Similarly, single-window systems can save resources, reduce human error and speed up trade flows. For instance, by launching a single-window system for cross-border trade, China largely reduced the time to clear imported goods at customs from seven days to 19.4 hours, and reduced the time for exports to 1.2 hours (Gov.cn, 2017).

## **2.3 Capitalising**

According to the theory of ambidexterity there are two ways of capitalising on the value created by the adoption of emerging technologies by deploying digital technologies: a) to enhance

existing competencies for incremental operational gains or exploitation; and b) to build new competencies and even new business models for strategic and radical gains or exploration (Raisch et al., 2009; Lee et al., 2015; Han et al., 2017).

#### *Exploitation - next generation smart logistics operations*

In today's highly competitive environment, the importance of digital technologies for ultimate success and, in some cases, even the survival of any logistics operation and initiatives, has been well recognized (Wang and Pettit 2016; Zhang et al., 2011). Improvements in customer service, operational efficiency, information quality and support of collaborative planning and execution, as well as improved responsiveness, are well acknowledged benefits (Gunasekaran et al., 2017; Giusti et al., 2019). The number of technologies used today for FTL is significant. We comment on some latest developments here.

IoT devices well embedded in transport networks, shipping containers, vehicles and people, provide great volumes of data, both structured and unstructured (e.g. video), thus offering new insights for experimentation, predictive planning, maintenance and delivery (Zhu et al. 2019). For instance, data collected from various sensors can be used to improve life-cycle asset management and support the concept of total preventive maintenance – particularly important for asset-heavy sectors such as FTL.

In addition to IoT generated data and data from conventional organizational information systems such as enterprise resource planning (ERP) systems, and emerging *social media* from sources such as Twitter and Facebook posts, data are increasingly made available and being exploited for nuisances and new insights. Structured and unstructured data collected from multiple sources in large volume and velocity has led to an explosion in the amount of data captured, and has subsequently challenged the information processing capability of traditional database software tools. It is within this context that the concept of *big data* and its management emerged.

As a result, big data analytics have become more prominent, resulting in transformative, strategic-level impact (Wamba et al. 2015). For example, dynamic transport planning and timetabling using real-time data from smart objects would allow simultaneous cargo- and carrier-tracking maximising transport infrastructure capacity. Big data has been used for driver behaviour, safety and fatigue management (Hopkins and Hawking 2018). Insights generated by analysing large volumes of social media data using sentiment analysis have been found effective in identifying factors affecting consumer satisfaction and improving supply chain management (Singh et al. 2018). Big data analytics also plays a critical role in supporting various practical, sector-specific initiatives, such as digital rail, smart motorways and smart port programmes (Wang 2019; Govindan et al., 2018).

The growing availability of big data, powerful graphics processing computing power, and increasingly sophisticated algorithmic models fuel the rapid development of *artificial intelligence (AI)*. This situation is especially pertinent for the area of machine learning and its subfield deep learning. AI has dual capabilities to support both exploitation and exploration. In terms of exploitation, some of the most notable applications focus on automating and optimising existing operations. For example, Wang et al. (2021) has identified that the use of AI for service operations planning and automated inventory replenishment has yielded significant benefits, including accuracy of planned task completions improving from 80.3%

(manual) to 90.5%, 3% increase in demand forecast accuracy, 10% increase in resource productivity and 60% reduction in volume of misplaced items/materials. In port terminals, production assembly lines, fulfilment centers, and last mile deliveries, we witness increasing automation to reduce manual handling and use of AI powered autonomous guided vehicles for goods movement and robots for specific tasks such as picking, sorting and packing (Dekhne et al., 2019).

#### *Exploration - radical changes and new supply chain models*

Companies need to continuously explore the innovative ways to capture revenue, structure enterprise activities and stake a position in new or existing industries. Technological innovation and digital transformation play a critical role leading to new ways of doing business as well as entirely new business models in logistics and supply chains (Goldsby and Zinn 2016). For instance, Mark and Shen (2020) discuss an emerging mode of supply chain innovation termed as consumer-to-manufacturer (C2M) model and use the case of JD.com to illustrate how C2M establishes digital links between end consumers and upstream manufacturers and product designers, and provides a variety of tactics to shorten the information flow process of the supply chain.

Those radical developments may drive paradigm changes. For instance, Berman (2012) finds that engaging with customers at every value creation point—not just sales, marketing and service but also product design, supply chain management, IT and finance—is what differentiates a customer-centered business from one that simply targets customers well. Customer interaction in these areas often leads to open collaboration that accelerates innovation through online communities. Esper et al. (2021) further argue that the age of consumer-centric supply chain management is beginning and arising from social and technological changes over the past 20 years coupled with the effects of the COVID pandemic. They advocate that the entire supply chain should focus on consumer experience rather than on mere customer service.

One noteworthy emerging technology that brings radical change to FTL is distributed ledger technology (DLT) or blockchain. A DLT is a shared, distributed ledger of records or transactions, open to inspection by every participant, but not subject to any form of central control (Pilkington 2016). Although it is still in its infancy, many believe that DLT is a ‘game changer’ for its potential impact on supply-chain structures, relationship configurations and cash flows (Esmailian et al., 2020; Wang et al., 2018). For the FTL sector, the value of DLT lies in its extended visibility and traceability, a reduction in the number of intermediaries in the supply chain, incentivising green behaviour via tokenization, and benefits for secure data management and smart contracts (Esmailian et al., 2020; Wang, 2021). For example, in the shipping sector, various pilot schemes use DLT to facilitate information-sharing among stakeholders, shipment booking and real-time container monitoring (Yang 2019).

Though most use cases of blockchain in FTL attempt to enhance current operations by taking time or cost out of the supply chain, emerging efforts are resulting in fundamental changes to organisations. For instance, TradeLens, jointly developed by IBM and A.P.Moller-Maersk, is a global supply chain platform underpinned by blockchain technology, aiming to bring together parties in the supply chain—including traders, freight forwarders, inland transportation, ports and terminals, ocean carriers, customs and other government authorities—onto a single platform in order to support secure exchange of information, foster greater collaboration and trust across the global supply chain (IBM News 2019).

Another interesting development, albeit still in its infancy, are decentralized autonomous organizations (DAOs). A DAO is a new organizational form where the management and operational rules are typically encoded within a blockchain in the form of smart contracts, and can autonomously operate without centralized control or third-party intervention (Wang et al., 2019). One can envision that a temporary supply chain could be built in the form of DAOs and then dissolve once it accomplishes its goals.

The technology landscape is evolving at an unprecedented pace. While not all emerging technologies will cause profound changes in the FTL sector, some—as discussed in this section—have the potential to disrupt the status quo; although many barriers still exist (e.g. see Kouhizadeh, et al., 2021).

### **3. Introduction to virtual special issue papers**

We received over 30 manuscripts for consideration in this virtual special issue. Each of them was of exceptional quality and of these, the best six papers were included. Each paper was reviewed by at least two peer expert reviewers. Manuscripts went through multiple cycles of revisions. The resulting published papers are classified based on the three themes discussed in Section 2 and summarised in Table 1. We now offer a brief overview.

#### ***3.1 Collaborating - digital platforms and ecosystems***

Choi (2020) considered the presence of an Internet based logistics platform that can offer flexible capacity elastically to respond to changing market situation in the fashion apparel industry. This study analytically derives via stochastic dynamic programming the optimal transportation option selection and inventory ordering policy with the elastic logistics platform (ELP). It examines the value of ELP and identifies the situations in which it is especially beneficial to adopt it according to fashion brand's need under quick response.

Xu, et al. (2020) investigated an emerging phenomenon of mega-online platforms in China and how a supply chain consisting of a manufacturer and a retailer should coordinate for optimal gains when selling products through an offline channel and an online platform. Specifically, they examine two contracts exploring the optimal operational decisions with Stackelberg game models: wholesale price contract and delivery cost sharing contract. The research finds that the supply chain can be coordinated via both contract mechanisms when platform power is large, and even if platform power is small, the supply chain can still be coordinated via cost-sharing contract when delivery time sensitivity is relatively high.

#### ***3.2 Capitalising - next generation smart logistics operations***

Fazi et al. (2020) studied a typical planning problem in inland container shipping, concerning the barge transportation of maritime containers between a dry-port and a set of seaport terminals with the goal to find the best allocation of containers to barges to guarantee on-time delivery and meet capacity restrictions. A hybrid local search meta-heuristic algorithm combined with a branch-and-cut solver was proposed to solve the problem, with input data collected from local barge operator in the Port of Rotterdam region. Numerical experiments showed a satisfactory performance of the proposed model. The research also highlights the need of IT platforms endowed with optimization algorithms to support the decision making of planners.

Miller et al. (2020) introduced a convex programming model with the key objective of scaling trajectories in order to obtain a data set that resembles the entire population of trips. The model yields significantly better results than its counterpart from the literature. The resulting data set can then be used for big data analysis of origin–destination patterns, link-based volumes, and various performance measures that are easily derived from trajectories (e.g., vehicle-hour delays, vehicle miles travelled).

Yavas and Ozkan-Ozen (2020) investigated what criteria are important for logistics centres in Industry 4.0 and explored the interrelationship between those criteria using Fuzzy DEMATEL method. They identified 12 critical criteria, of which Digital information platforms, intelligent transportation systems, and smart mobility were the most important criteria for Logistics Center 4.0. Digital information platforms was the most powerful criterion in terms of affecting the others.

### ***3.3 Capitalising - new business and supply chain models***

Orji et al. (2020) used a technology-organization-environment (TOE) theoretical framework to identify critical factors that influence the successful adoption of blockchain technologies in the freight logistics industry and prioritize them using the analytic network process (ANP). The research findings indicate that ‘availability of specific blockchain tools’, ‘infrastructural facility’, and ‘government policy and support’ are the three topmost ranked significant factors that influence the adoption of blockchains in the freight logistics industry.

Table 1: Summary of the selected papers for the virtual special issue on Emerging Digitalisation Technologies in Freight Transport and Logistics

Papers	Theme	Focus	Research questions/objectives	Contribution
Choi, T.-M. (2020).	Collaborating	Supply chain collaboration (Platform ecosystem)	To address the problem of optimal transportation option selection and inventory ordering policy with the internet based elastic logistics platform (ELP).	Constructed an analytical model that explores the ELP's value and uncover how it affects fashion retail operations with respect to ordering and transportation mode selection decisions.
Xu, X., Zhang, M., & He, P. (2020).		Supply chain collaboration (Platform ecosystem)	To investigate the coordination problem of a supply chain consisting of a manufacturer and a retailer who sells products through an offline channel and an online platform.	The supply chain can be coordinated via wholesale price and cost-sharing contracts when platform power is large, and even if platform power is small, the supply chain can still be coordinated via cost-sharing contract when delivery time sensitivity is relatively high.
Fazi, S., Fransoo, J. C., Van Woensel, T., & Dong, J.-X. (2020).	Capitalising (exploitation)	Next generation smart logistics operation (machine learning, meta-heuristic)	To address the problem of planning the transportation of maritime containers between a dry port and seaport terminals by barge.	A hybrid local search meta-heuristic algorithm, combined with a branch-and-cut solver, was developed to solve the modelled problem. The proposed framework complements existing models in the literature and contributes to the development of a comprehensive set of decision support tools for inland terminals.
Miller, S., Laan, Z. Vander, & Marković, N. (2020).		Next generation smart logistics operation (big data analytics, IoT)	To address the problem of inferring state-wide traffic patterns by scaling massive GPS trajectory data.	The paper proposes a least absolute deviations model that reduced the median station error across test locations by 45%, from 32% to 18%.
Yavas, V., & Ozkan-Ozen, Y. D. (2020).		Next generation smart logistics	To reveal the important criteria for logistics centers in Industry 4.0	A framework, via Fuzzy DEMATEL, was developed, including 12 critical criteria that are expected to shape the new logistics centers.
Orji, I. J., Kusi-Sarpong, S., Huang, S., & Vazquez-Brust, D. (2020).	Capitalising (exploration)	New business and supply chain models (Distributed trustless network)	To evaluate the factors that influence blockchain adoption in the freight logistics industry.	The paper proposes a TOE theoretical framework of critical factors and prioritize them using ANP.

#### 4. Future research opportunities

When launching the call for this virtual special issue, we were interested in a variety of topics. Whilst the selection of papers certainly addresses a few of those topics, there are some important research areas which received no submissions. This gap indicates that there is substantially more scope and opportunities for high quality future research. Although the topics covered by this virtual special issue studies generate more streams of research, we also provide a list of additional opportunities that still remain that none of the articles for this virtual special issue cover.

- Diffusion of digitalization technologies across various freight transport and logistics industries
- Theoretical developments and rethinking theory in this emergent digitalization environment using formal analytical modelling
- Advancing analytical modelling and decision making for the planning, integration, adoption, and maintenance of emergent technologies
- Systems and adaptive model requirements in the integration of transportation technological systems; their interaction and standalone capabilities and limitations
- The social, environmental, and economic implications of digitalization technologies on industry, community and regulatory policy for freight transportation
- Entrepreneurial activities in freight transport and logistics and how industry business models may change
- Operations and supply chain modelling for emergent digitalization of freight transport and logistics
- Technological forecasting and outcomes including potential roadmaps based on theoretical, historical, and scenario planning for freight transportation and logistics
- Competitive and game theoretic modelling aspects of emergent digitalization of freight transport and logistics
- Big data, predictive analytics and decision making in freight and logistics optimisation
- Data driven business models and concepts
- Intelligent freight transport concepts (e.g. digital rail, smart motorways and smart port) and their implications
- Applications of artificial intelligence such as robotics and truck platooning, machine learning and virtual agents in freight transport and their disruptive effect
- Immersive technologies (such as augmented, mixed or virtual reality), simulation and behavioural change
- The emergence of distributed ledger technology/blockchain technology and its value creation in logistics and freight transport e.g. smart contract, product provenance, asset management and disintermediation
- Effects of social media networks and social commerce on freight transport and logistics
- Industry 4.0, IoTs and digital twin and related structural, process and relational changes imposed
- Intersection between various digital technologies and their integrative impact on future of mobility
- Applications of new technologies in freight urbanisation, cross-border integration, multimodality and sharing economy

One under-researched theme is *connecting* (section 2.1) and includes possibilities of recent developments in digital infrastructure such as 5G, edge computing and digital twins. Given these infrastructural topics play important enabling roles, their impact is often assessed via the applications that build upon them. As an example, although implications of real time tracking systems on delivery performance and customer satisfaction may be investigated, they have not directly considered into how a 5G supporting network may have contributed to the performance outcomes. Diving deep into this area could lead to fruitful insights as they lay the foundation to many innovative business activities and business models. Understanding the realm of possibilities afforded by these advances could enable academic researchers and practitioners to go beyond observation of existing phenomena and actively explore the innovative ways of utilising those advances for sustainable outcomes.

Thus, we champion more inductive and exploratory research for theory development and subsequently theory testing in the realm of this virtual special issue and related topics. We observe that the methodological approaches deployed by the papers in Table 1 are mostly analytical, this approach has its constraints when it comes to explorative studies. Therefore, future research in examining emerging technologies in FTL should utilise a diverse range of methodological approaches, for instance design science, survey, case study and behavioural experiments.

In addition to the need for diverse methodological approaches, there is also a need for diversity in theoretical approaches—as evidenced by this special issue. The choice of the theoretical perspective for a topic and the observed situation influences the aims and research questions as well as the methodology, and vice versa. Since emerging digital technology is a multi-faceted phenomenon-offering significant complexities—which cannot be described, understood or explained by one monolithic theoretical approach alone, a variety of theoretical perspectives and approaches is necessary to give justice to the complexity of the field.

Finally, in-depth studies examining specific digital advances outlined in Section 2 would enrich the digitalisation and digital transformation literature; some advances would likely be more pertinent than others to FTL. The special issue has examined platforms, IoT and blockchain technologies in some specific contexts, but there are many more innovations we are yet to fully understand and grasp from an FTL, implications perspective, particularly given their infancy as can be identified along the Gartner hype cycle (Dedehayir and Steinert, 2016). The opportunities are extensive, for example, interesting avenues for research could include truck platooning, VR/AR, social media platforms and new business models considerations such as circular supply chain and sharing economy, to name only a few here.

## **5. Concluding remarks**

In this virtual special issue we incorporated a compilation of high-quality research studies that can help understand and influence practice and theory on the latest technological developments on FTL and at many levels. The six papers included in this virtual special issue offer valuable insights into this fast-developing field of digitalisation in FTL. We believe our efforts bring together some of the current rather fragmented and disjointed research efforts on emerging technologies in logistics and transportation to help improve their relevance to the transportation discipline becomes apparent. We also hope our efforts will encourage further research interests from the academic community into this important field.

Scholars that are interested in recent developments in various transport modes (road, rail, air and water), at critical supply chain nodes (airport, seaport, distribution centers, and cross-borders and at different levels (intra and inter-organisational, regional, and global) would gain some leverage from the emerging technological landscape. Younger transportation scholars could gain valuable insights about the application and impact of emergent digitalization technologies on the theory and practice of freight transport and logistics. IS/IT scholars could benefit from insights and knowledge generated from the cross-disciplinary studies afforded by this SI and understand the contextualised impact and application of those emerging technologies.

We also hope that practitioners from transport service providers, shipping lines, rail/road/air/water/port transport operators, freight forwarding companies, manufacturing companies, retailers, infrastructure owners, IT service providers as well as public authorities and trade associations will be able to leverage the special issue in making a strategic sense of the disruptive effect and potential opportunities/challenges afforded by those emerging technologies to logistics and transportation.

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