

A blockchain-enabled framework for sharing logistics resources in emergency operations

This paper presents a conceptual research work designed to study how the sharing economy concept can be leveraged to increase the participation of commercial organisations (transporters, retailers, etc.) in disaster relief operations. Drawing on Social Exchange Theory, the academic literature on the sharing economy and blockchain, as well as existing resource sharing practices in both commercial and humanitarian logistics operations, this paper develops a theoretical framework for analysing the structure, benefits and prerequisites of a logistics sharing system in emergency responses. It also proposes to utilise the blockchain technology to facilitate the interactions and enhance trust between emergency responders and commercial organisations. It is argued that leveraging commercial logistics resources such as emergency supplies, transport capacity and storage space has the potential to improve the mobilisation and deployment of urgently needed relief items and increase the flexibility of emergency responses.

Keywords: disaster relief, emergency operations, humanitarian logistics, sharing economy, resource sharing, blockchain, Social Exchange Theory, supply chain collaboration, trust

Introduction

When a disaster strikes, relief operations must be organised rapidly and emergency supplies must be mobilised and deployed immediately. However, inefficiencies are common in relief operations, including fragmented operations, unconsolidated shipments, the lack or under-utilisation of resources, and delayed deliveries (Altay and Labonte, 2014). For example, a recent emergency plan put together by the Wellington Regional Emergency Management Office indicates that it could take up to one week for the first emergency supplies to be delivered to the affected communities in the case of a 7.5-magnitude earthquake occurring in the New Zealand capital (George, 2018).

Since responding to a major disaster is typically beyond the capacity of a single organisation, inter-organisational collaboration is essential in emergency operations. This includes working

with commercial organisations that often have the willingness and the ability to make a valuable contribution to the relief efforts (Swanson and Smith, 2013), as illustrated by Walmart's rapid transport and deliveries of urgently needed relief supplies in the wake of Hurricane Katrina (Horwitz, 2009). Therefore, government agencies must be able to rapidly connect and work with commercial actors such as retailers, transporters and logistics service providers. As discussed by Vega and Roussat (2015), logistics service providers play a critical role in disaster preparedness, response and recovery operations. They offer a large variety of services to both governmental and non-governmental organisations whose core competencies do not include logistics (Abidi, de Leeuw, and Klumpp, 2015). The logistics services provided include transport, customs clearance, warehousing, stock management, packing/repacking, labelling, fleet management, distribution, and reverse logistics (Abidi et al., 2015; Vega and Roussat, 2015). A number of studies (e.g. Balcik, Beamon, Krejci, Muramatsu, and Ramirez, 2010; Vega and Roussat, 2015) explain that the role of logistics service providers ranges from operators (performing logistics operations) to strategic partners (designing and running integrated supply chain solutions). According to Abidi et al. (2015), involving logistics service providers in relief operations improves communication and collaboration among relief supply chain actors by standardising processes and integrating information systems, which in turn enhances the quality of the logistics services provided. Logistics service providers see their involvement in disaster relief not only as a business opportunity, but also as a way of fulfilling their corporate social responsibility (Vega and Roussat, 2015).

The sharing economy has the potential to enable swift and flexible interactions between governmental emergency management authorities, non-governmental agencies and business organisations. Also known as peer economy or collaborative consumption, the sharing economy is a rapidly developing model for offering and consuming goods and services. With several thousand platforms supporting the access to resources (rather than ownership), the sharing economy has become an integral part of our society and economy (Rinne, 2019). As observed in the Wall Street Journal, "there is an Uber for everything now" (Fowler, 2015), from farming equipment (e.g. MachineryLink Sharing) to fashion items (e.g. Style Lend).

Since the sharing economy is fuelled by both changes in consumption preferences and technological advancements, Hamari, Sjöklint, and Ukkonen (2016) describe it as a socio-technological phenomenon. In particular, the recent literature (e.g. Hawlitschek, Notheisen, and Teubner, 2018) takes an interest in the potential of the blockchain technology to streamline transactions and build trust within sharing networks. Blockchain's appeal is due to the

technology's ability to create transactional efficiency and support on-demand exchanges between parties that do not know each other (Piscini, Hyman, and Henry, 2017).

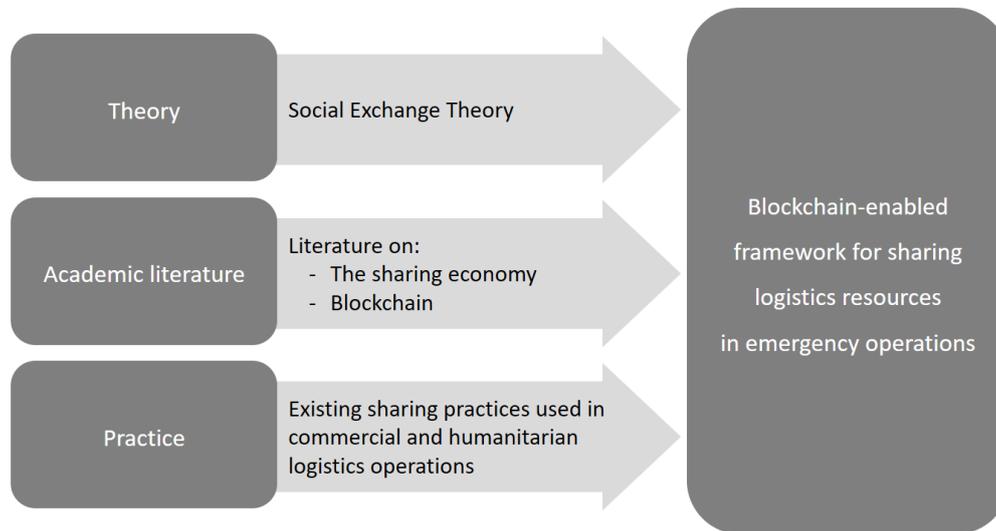
The sharing economy and blockchain appear to be adapted to disaster relief operations where responders operate with limited capacity and must make rapid decisions regarding the integration of various actors (governmental, non-governmental, business actors) and the mobilisation of their resources (Swanson and Smith, 2013). Yet, these topics have received little attention in the disaster management literature. Aranda, Fernández, and Stantchev (2019) explore the use of blockchain to improve communication and collaboration along humanitarian supply chains. Going one step further, Dubey, Gunasekaran, Bryde, Dwivedi, and Papadopoulos (2020) show that blockchain supports the building of swift trust among organisations involved in disaster relief operations and, ultimately, increases the resilience of humanitarian supply chains. Focusing more specifically on humanitarian-business relationships, Baharmand and Comes (2019) discuss the use of smart contracts to enhance trust and transparency between humanitarian organisations and logistics service providers. Although the number of papers on blockchain in humanitarian logistics is increasing, little is known about how this technology can be used to support the sharing of logistics resources in emergency responses.

The objective of the current study is, therefore, to investigate how the sharing economy concept (supported by the blockchain technology) can be used to leverage commercial logistics resources in disaster relief operations. This paper studies resources from a logistics perspective, which includes supply, transport and storage. Supply refers to the acquisition of the items needed in disaster relief operations (e.g. shelter items, medical equipment, power generators, etc.). Transport supports the movements of goods along the relief supply chain and storage refers to the process of holding the goods until they are needed in emergency operations. These three key logistics processes, which create substantial challenges in the aftermath of a disaster, are critical to the success of the relief efforts since they enable the emergency supplies to be available when and where they are needed by the affected communities (Haavisto, Tatham, Harilainen, L'Hermitte, Laarson, and Vaillancourt, 2018).

To explore how emergency responders can work with commercial businesses willing to make their resources available in an emergency, this paper draws on theoretical foundations (Social Exchange Theory), the academic literature on the sharing economy and blockchain, as well as existing resource sharing practices used in both commercial and humanitarian logistics operations. These theoretical, academic and practical perspectives are then integrated into a

single conceptual framework for analysing the structure, benefits and prerequisites of a logistics sharing system that supports emergency responses. Figure 1 illustrates this approach.

Figure 1. Development of the conceptual framework



Source: authors.

The remainder of this paper is structured as follows. The following section introduces Social Exchange Theory as the theoretical foundation used in this paper. Then, the literature on the sharing economy is examined and the use of the blockchain technology to support sharing practices is explored. The subsequent section focuses on the application of the sharing economy to commercial logistics and emergency operations. Next, a conceptual framework for sharing logistics resources in emergency operations is presented, followed by a section that identifies the contributions/limitations of this study and develops a research agenda to guide further research. The final section provides concluding comments.

Theoretical foundations

In this paper, Social Exchange Theory (SET) is used to shed light on the mechanisms underlying the development of exchange interactions among organisations and, ultimately, to conceptualise the framework for involving commercial organisations and leveraging their resources in emergency operations.

SET is a major theory of social interaction that has its roots in the field of sociology with the work of early theorists such as Homans (1958), Blau (1964) and Emerson (1976). SET studies social relations and posits that an exchange results from a costs and benefits analysis

(Cook, 2015). In particular, parties compare the relative costs and advantages of various exchange transactions and engage in exchanges that maximise value (Homans, 1958). SET also explores the role of rules and norms that govern relationships (e.g. Emerson, 1976) and examines how mutual trust is built over time (Cropanzano and Mitchell, 2005). Using the core research papers on the theory, Lambe, Wittmann, and Spekman (2001) identify the following foundational premises and confirm that all four apply to both individual and business exchanges:

1. Benefits
2. Relative advantage
3. Trust
4. Norms

Benefits are the economic and social outcomes resulting from exchange interactions. More specifically, a transaction generates economic benefits (e.g. money) and/or social benefits (e.g. altruistic contribution, sense of belonging) that, together, determine the overall outcome of the exchange relationship. According to SET, the benefits of a social exchange are compared to the potential benefits of alternative exchange interactions, i.e. the benefits that could be gained from another form of exchange or from an exchange with a different partner. Thus, the *relative advantage* of an existing exchange relationship determines whether parties continue or terminate the relationship (Lambe et al., 2001).

The concept of *trust* has been considered as one of the most critical elements of SET, both in the foundational papers about the theory (e.g. Blau, 1964; Homans, 1958) and in those considering the theory in the business-to-business (B2B) context (e.g. Morgan and Hunt, 1994; Smith and Barclay, 1997). Trust has been defined as the belief that an exchange is reliable and that parties will fulfil their obligations (Lambe et al., 2001). In the words of Arrow (1974, p. 23), “trust is an important lubricant of a social system”. Typically, trust is built over time from repetitive, positive exchange interactions (Cropanzano and Mitchell, 2005). However, as discussed by Meyerson, Weick, and Kramer (1996), trust may also have to be established rapidly, for example when temporary organisational structures must be operative and deliver results within a short period of time (e.g. when a group of people or organisations is brought together to complete a specific, short-term project). Called *swift trust*, this model is relevant to digitalised organisational structures and the sharing economy where participants build temporary relationships within short time frames (Blomqvist and Cook, 2018). As will be discussed in the next section, *swift trust* is a recurrent concept in the sharing economy literature.

Swift trust arises from mechanisms such as reputation, clearly defined roles and expectations, the ongoing exchange of information, as well as consensual norms and rules (Meyerson et al., 1996). Tatham and Kovács (2010) apply the concept of swift trust to the humanitarian logistics environment where multiple aid agencies operate within ad hoc and hastily formed networks.

Norms are another critical element of SET. Norms are defined as the rules of the exchange process, namely the mechanisms that regulate the parties' interactions and actions (Cropanzano and Mitchell, 2005; Lambe et al., 2001). Thus, norms guide behaviour, facilitate social interactions and increase transactional efficiency (Lambe et al., 2001). They can be tacit (e.g. an expectation of reciprocation) or explicitly negotiated (e.g. a B2B contract). Explicitly negotiated norms clearly describe the duties and obligations of the parties (Cropanzano and Mitchell, 2005).

Since its development in the late 1950s and early 1960s, SET has been used in multiple fields of study. Recent studies include supply chain management (Gligor, Bozkurt, Russo, and Omar, 2019), communication and knowledge management (Yan, Wang, Chen, and Zhang, 2016), sustainability (Su, Huang, and Pearce, 2018; Wang, Xiang, Yang, and Ma, 2019), governance and human resource management (Walckirch, Nordqvist, and Melin, 2018), and workplace relationships (Chernyak-Hai and Rabenu, 2018). SET has also been applied to the field of tourism, including loyalty programmes (Lee, Capella, Taylor, Luo, and Gabler, 2014) and the interactions and exchange process between resident and tourist populations (Bimonte and Punzo, 2016; Nunkoo, 2016; Özel and Kozak, 2017; Rasoolimanesh, Jaafar, Kock, and Ramayah, 2015). More specifically, SET has been used in tourism and hospitality to investigate the sharing economy concept and the importance of trust in exchange transactions (Altinay and Taheri, 2019; Kim, Yoon, and Zo, 2015). For example, Priporas, Stylos, Rahimi, and Vedanthachari (2017) examine how consumers perceive service quality in the shared lodging industry through the lens of SET. They find that the users of Airbnb accommodations rank trust-related elements such as convenience (including readily available information) and assurance (including the safety of the neighbourhood and the use of security systems) as the most important contributors to service quality. Similarly, using SET as a theoretical foundation, Boateng, Kosiba, and Okoe (2019) investigate what drives consumers to participate in the sharing economy and, in particular, what drives the use of Uber services. They identify trust, customer return on investment and convenience as the most important motivations.

The foundational premises of SET discussed in this section will form an integral part of the conceptual framework presented later in this paper. For now, the next section discusses the sharing economy concept.

The sharing economy

This section introduces the central theme of this paper. In particular, the meaning and the scope of the sharing economy are presented and the concept of trust, which is a central element in the sharing economy, is discussed.

The sharing economy is a model of consumption that is gaining momentum in today's economy with the prevalence of marketplace coordinators such as Airbnb and Uber. By driving new consumption behaviours and challenging traditional ways of offering and consuming resources, the sharing economy disrupts long-established market practices, for example in hospitality and transport (Acquier, Daudigeos, and Pinkse, 2017; Gesing, 2017). Since it was first introduced by Lessig (2008), the concept has been widely discussed in the literature. It has also generated a significant amount of confusion among researchers and the public (Frenken and Schor, 2017) as the term has been defined in multiple ways (Ranjbari, Morales-Alonso, and Carrasco-Gallego, 2018) and has been used to refer to a large variety of organisational forms and business models (Gerwe and Silva, 2019). Sharing economy practices range from non-profit networking services that support free sharing among participants (e.g. Couchsurfing) through to collectively owned and managed resources (e.g. heavy equipment shared between construction companies) and profit-driven multinationals operating giant commercial networks such as Airbnb or Uber (Gerwe and Silva, 2019). Irrespective of the model adopted, Hawlitschek et al. (2018) identify the following features of the sharing economy:

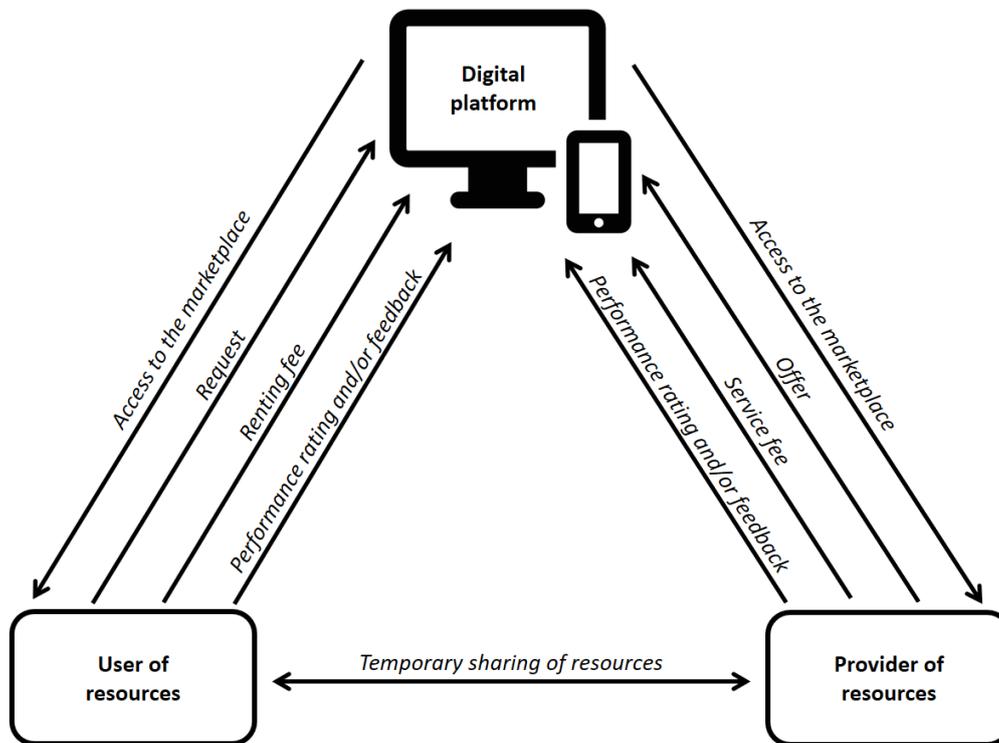
1. It facilitates peer-to-peer transactions;
2. It increases asset utilisation rates;
3. It enables temporary resource access;
4. There is no transfer of ownership, i.e. resources are returned to the owner after being used;
5. Shared resources are partly or fully tangible, i.e. physical goods;
6. Resources are shared in exchange for money or other form of compensation;
7. Digital technology is leveraged in the form of an online platform that facilitates interactions and transactions.

Summarising the above features, Hawlitschek et al. (2018, p. 52) define the sharing economy as “a peer-to-peer-based economic system in which tangible resources are shared, in effect increasing their utilisation. Transactions are of temporary nature, mediated through

online platforms, and reimbursed without transfer of ownership”. This definition is adopted in this paper.

As noted by Acquier et al. (2017), a digital platform is a critical element of the sharing economy. It creates value by connecting users and suppliers, by building an ecosystem of network participants, by facilitating resource access, by organising transactions, and by enhancing trust and transparency across the network (for example through ratings and feedbacks). Therefore, Hawlitschek et al. (2018) consider the digital platform as an integral part of the sharing economy alongside the providers and the users of resources. Figure 2 illustrates this tripartite model.

Figure 2. Sharing economy tripartite model



Source: adapted from Gesing (2017).

Gerwe and Silva (2019) identify the benefits of the sharing economy. These include user benefits such as greater variety, lower prices, a higher level of convenience and flexibility, as well as the ability to access resources without any investment in the assets used. For resource providers, the benefits are a steadier level of income and a higher level of asset utilisation. Broader economic advantages such as enhanced transactional efficiency and increased economic productivity have also been mentioned in the literature (Gerwe and Silva, 2019).

However, the development of the sharing economy is not without its challenges. In particular, the concept of trust is a prominent topic in the literature (e.g. Hawlitschek et al., 2018; Hawlitschek, Teubner, and Weinhardt, 2016; ter Huurne, Ronteltap, Corten, and Buskens, 2017). Trust is an issue because sharing economy marketplaces offer no opportunity for face-to-face communication. In addition, no prior personal or professional relationships have been built and exchange partners lack detailed information about each other (Botsman and Rogers, 2010). As noted by PWC (2015, p. 16), “convenience and cost-savings are beacons, but what ultimately keeps this economy spinning—and growing—is trust”. Therefore, sharing economy operators have developed multiple reputational mechanisms such as mutual reviews, feedbacks, rating schemes and seller verifications that assist the participants’ decision making (Botsman and Rogers, 2010; Hawlitschek et al., 2016).

Hawlitschek et al. (2016) develop a comprehensive model of trust in the sharing economy. In particular, they differentiate between two perspectives of trust (consumer and supplier) and three targets of trust (peer, platform and product). From the consumer perspective, trust includes trust in peer (the belief that suppliers have the skills required to fulfil their obligations), trust in platform (the belief that the platform has the ability to ensure successful peer mediation) and trust in product (the belief that the product characteristics are as expected and that the product will fulfil its functions). From the supplier perspective, trust includes trust in peer (the belief that consumers will take care of the product) and trust in platform (the belief that the platform has the ability to perform its mediating role appropriately). More specifically, trust in platform relates to transactional efficiency and includes elements such as reliable matches between consumers and suppliers, rapid interactions, an easy-to-use booking system, a secure payment process, and data security (Hawlitschek et al., 2016). The above trust model will serve as a basis to identify the key elements of trust integrated into the conceptual framework presented later. For now, the next section discusses how the blockchain technology can contribute to building trust in the sharing economy.

Using blockchain to build trust in the sharing economy

The development of the sharing economy is driven by the rapidly changing information and communication environment and the diffusion of Internet platforms that allow people and organisations to connect and share resources. Among the technologies available, blockchain has potential as it enhances trust and streamlines the interactions between multiple independent parties (Piscini et al., 2017).

Blockchain is a distributed ledger technology, namely a shared data platform that enables authenticated communication and the widespread sharing of real-time information among participants. The technology operates as a decentralised peer-to-peer network rather than a centrally managed interface deployed on the server of one organisation that controls the system and the data. Blockchain is seen as an alternative technology for building networks not only between people, but also between organisations (Kumar, Liu, and Shan, 2019). The first and best-known application of the technology is Bitcoin, a peer-to-peer digital cash system that enables parties to make payments without any financial institution acting as a trusted third-party intermediary (Crosby, Pattanayak, Verma, and Kalyanaraman, 2016).

Blockchain can be used to create digital agreements called smart contracts. A smart contract is a computer code embedded in the blockchain. It establishes a set of pre-determined conditions agreed upon by the participants, verifies the performance of the parties, and automatically executes the terms of the agreement as soon as pre-programmed conditions are met. Smart contracts are, therefore, enforced by computer protocols, without any human intervention and manual paperwork (Crosby et al., 2016).

The recent literature discusses not only the intersection of blockchain and the sharing economy (e.g. De Filippi, 2017; Hawlitschek et al., 2018; Pazaitis, De Filippi, and Kostakis, 2017), but also how blockchain is changing the sharing economy. In particular, it is considered as an alternative technology for today's centralised sharing economy platforms. Since blockchain enables the network participants to operate without the control of a central authority or governing body acting as a trusted intermediary in the market, the technology supports true peer-to-peer transactions. In other words, blockchain enables true sharing economy exchanges by connecting parties directly and eliminating the need for platforms such as Uber or Airbnb that capture large portions of the profits generated by the sharing of resources (De Filippi, 2017; Lundy, 2016). A number of sharing networks (e.g. the carpooling platforms La'Zooz and Arcade City) already operate independently of any central organisation by using blockchain to manage the interactions and transactions between drivers and users of ride-sharing services (De Filippi, 2017).

The literature also explores how and the extent to which blockchain establishes and maintains trust in the sharing economy. In the words of Piscini et al. (2017, p. 93), "blockchain is assuming the role of trusted gatekeeper and purveyor of transparency". It enables the safe and efficient exchange of resources between parties that do not know or trust each other. Firstly, trust and transparency come from blockchain's ability to store and share valuable information such as histories, safety records, transaction logs, etc. Blockchain, therefore, is the repository

of critical information that increases the network participants' control on exchange transactions (Piscini et al., 2017). Secondly, trust is the result of blockchain creating a trail of secured, immutable and shared transaction records that lead back to the network participants through a system of cryptographic signatures. Thirdly, trust is generated by the technology's ability to create consensually agreed norms (also called consensus protocols) that cannot be unilaterally manipulated. These terms and conditions are recorded in the system's algorithms and in the smart contract codes. Fourthly, trust originates from the automated execution of the contracts (self-executing smart contracts) and the automated monitoring of the parties' compliance with the terms and conditions. Pre-agreed transactions take place automatically as soon as the conditions of the contract are met, i.e. without friction or risk of error (Beck, Stenum Czepluch, Lollike, and Malone, 2016; Hawlitschek et al., 2018; Piscini et al., 2017).

Blockchain is seen as a disruptive technology offering tremendous opportunities in logistics and supply chain management. Combined with technological developments such as RFID, the Internet of Things and data analytics, blockchain is predicted to transform supply chain operations and significantly increase traceability, transparency, visibility, trust (Pournader, Shi, Seuring, and Koh, 2019; van Hoek, 2019b) and resilience (Min, 2019). By breaking down data silos and enhancing B2B integration, blockchain enables supply chain organisations to answer questions such as 'Where is my container?' or 'Under what conditions were my products transported?' (Vyas, Beije, and Krishnamachari, 2019). More specifically, blockchain records the physical movements of goods, tracks every transaction (from the order to the receipt of the goods, the invoice and the payment), eliminates paperwork and, ultimately, contributes to reducing errors, delays and costs along the supply chain (Tijan, Aksentijević, Ivanić, and Jardas, 2019). According to Kshetri (2018), who studied eleven supply chain management-related blockchain projects (Maersk, Provenance, Alibaba, Everledger, Walmart, etc.), the technology is also set to affect quality, speed, dependability and flexibility along the supply chain. By establishing provenance knowledge and, thereby, reducing the consumer risk perceptions, blockchain has the potential to add considerable value to supply chain operations in a variety of industries (Montecchi, Plangger, and Etter, 2019), including pharmaceuticals (Heutger and Kückelhaus, 2018), luxury items, and agri-food products (Caro, Ali, Vecchio, and Giaffreda, 2018; Casado-Vara, Prieto, De la Prieta, and Corchado, 2018; Tian, 2016).

Despite the hype and the multiple public announcements regarding the development of blockchain applications in supply chain management (Petersen, Hackius, and von See, 2018), a number of barriers still hinder the widespread adoption of the technology. Saberi, Kouhizadeh, Sarkis, and Shen (2019) group these barriers into four categories: intra-organisational barriers

(e.g. the lack of expertise and cultural constraints preventing the conversion to new systems), inter-organisational barriers (e.g. the reluctance to share information with supply chain partners), system-related barriers (e.g. the immaturity of the blockchain technology), and external barriers (e.g. the lack of governmental policies and integration in the logistics industry). Although blockchain generates growing interest in the supply chain management discipline with an increasing number of publications, empirical research remains limited (Pournader et al., 2019; van Hoek, 2019a) and theory-based studies are needed to build the theoretical foundations for blockchain research in supply chain management (Treiblmaier, 2018).

This paper's conceptual framework for sharing logistics resources will utilise blockchain as a tool to create trust and streamline the interactions and transactions between emergency responders and commercial organisations. Before doing so, the next section explores how the sharing economy has been applied to the fields of commercial and emergency logistics operations.

Sharing logistics resources

Commercial logistics operations

Although the application of the sharing economy to logistics is gaining ground and practitioners, industry analysts and consultants take an active interest in this topic (e.g. Deloitte, 2016; Gesing, 2017), the related academic literature is limited. Research widely discusses associated topics, such as horizontal collaboration in logistics (Crujssen, Dullaert, and Fleuren, 2007), logistics/supply chain pooling (Ballot and Fontane, 2010) and joint warehouses operated by a third-party logistics providers (Franklin and Spinler, 2011) but these studies do not fall under the umbrella of the sharing economy as previously defined and illustrated in Figure 2.

Actual sharing economy examples can be found in the logistics practice such as transport and warehousing. In the transport industry, digital freight brokerage platforms such as Uber Freight, Cargomatic, Freightos and Saloodo! offer B2B on-demand transport services by bringing shippers and carriers together on an online platform. Advantages for carriers include the reduction of empty miles, less vehicle idle time and, therefore, a better load and asset utilisation. From the shipper perspective, on-demand transport streamlines shipping operations and increases transport flexibility across all modes (Gesing, 2017).

In warehousing, sharing economy practices include the temporary supply of and demand for storage space on an online platform. Such services are offered, for example, by Flexe that provides on-demand warehousing services. Flexe's services are powered by a digital platform that connects providers and users of storage capacity and ensures visibility over a network of

over 1,000 warehouses (Flexe, 2019). SecūrSpace is another example that illustrates the development of digital marketplaces for storage space. SecūrSpace offers on-demand access to yard and parking facilities for trucks, trailers and containers in the United States (SecūrSpace, 2019). Shared warehousing and storage solutions enable companies to maximise their available space and generate additional revenue streams. From the user perspective, shared warehousing and storage initiatives offer flexible storage solutions across multiple locations and closer to demand (Gesing, 2017).

Emergency operations

Similar to research in commercial logistics, the sharing economy concept has not been explored in the disaster management literature but related topics have been examined. For example, inter-organisational collaboration is widely studied in the humanitarian logistics literature (e.g. Balcik et al., 2010; Bealt, Fernández Barrera, and Mansouri, 2016; Schulz and Blecken, 2010) and in the broader disaster management literature (e.g. Kapucu, Arslan, and Demiroz, 2010). According to Balcik et al. (2010), inter-organisational collaboration contributes to improving the deployment of humanitarian supplies and to reducing the response time.

The relationships between public responders and private organisations have also been investigated. In particular, Gabler, Richey Jr., and Stewart (2017) focus on the temporary collaborations that government agencies and private companies establish in order to support the communities affected by a disaster. Their research shows that successful emergency operations depend on the rapid mobilisation of logistics and supply chain resources provided by private organisations. For example, evacuating thousands of people affected by a disaster requires government agencies to collaborate with transport organisations that have the resources needed for mass evacuation operations. Gabler et al. (2017) note that pre-established public-private partnerships (i.e. prior to the disaster occurrence) speed up the mobilisation of resources. For instance, Red Cross was able to swiftly mobilise Coca-Cola's bottling capacity in the immediate aftermath of the 2004 South-East Asian tsunami and rapidly access bottled drinking water because the partnership between the two organisations was already in place when the disaster occurred (Thomas and Fritz, 2006).

However, experience shows that not all public-private collaborations are successful. In high-stress disaster environments where external resources must be mobilised immediately and decisions must be made promptly, there is no time to determine which best resources are available and to build trust with organisations willing to participate in the relief efforts. In this context, humanitarian contracts might be awarded to inexperienced and/or unreliable

organisations unable to honour their commitments. This happened, for example, in 2017 when an organisation contracted by the American Federal Emergency Management Agency (FEMA) was able to deliver only 50 thousand meals out of the 30 million ordered in the wake of Hurricane Maria in Puerto Rico (Mazzei and Armendariz, 2017).

The above research on inter-organisational relationships and on public-private partnerships in disaster relief is relevant to the focus of this paper but the literature dedicated to these topics does not discuss the sharing economy. However, actual practices implemented by humanitarian organisations can be examined and drawn upon. For example, the practices of the United Nations (UN) Logistics Cluster provide valuable insights. The Logistics Cluster is a voluntary coordination body that brings together humanitarian organisations and enhances information and resource sharing in logistics matters. Led by the UN World Food Programme (WFP), the Logistics Cluster coordinates the logistics activities of multiple relief agencies (both UN and non-UN agencies) involved in operations that require joint preparedness (e.g. joint stockpiling) and a joint response (e.g. joint transport) (Jahre and Jensen, 2010; Logistics Cluster, 2019). For example, WFP and the Logistics Cluster support the sharing of transport capacity among relief agencies when a shortage of trucks causes delays in the deliveries of relief items as well as the sharing of warehouse space when storage capacity is scarce in disaster-affected areas (L'Hermitte, Tatham, and Bowles, 2014). Ultimately, the Logistics Cluster supports the pooling and sharing of logistics resources such as transport and storage but it is a coordination mechanism managed by WFP rather than a sharing economy-based, digitally enabled marketplace facilitating exchanges.

Beyond transport and storage, a number of initiatives show the potential of tapping into existing sharing economy platforms to support relief efforts. For example, using Airbnb greatly simplifies the process of finding accommodation for displaced people. During Hurricane Sandy, that hit the East Coast of the United States in 2012, Airbnb engineers quickly adjusted their booking and payment systems to accept fee-free listings and enable hosts to offer free-of-charge temporary accommodation to displaced people and relief workers (Brown, 2014). Shortly after, Airbnb worked with several American cities and developed a dedicated platform that connects displaced persons and relief workers with hosts willing to open their doors at no cost (Airbnb, 2013, 2019).

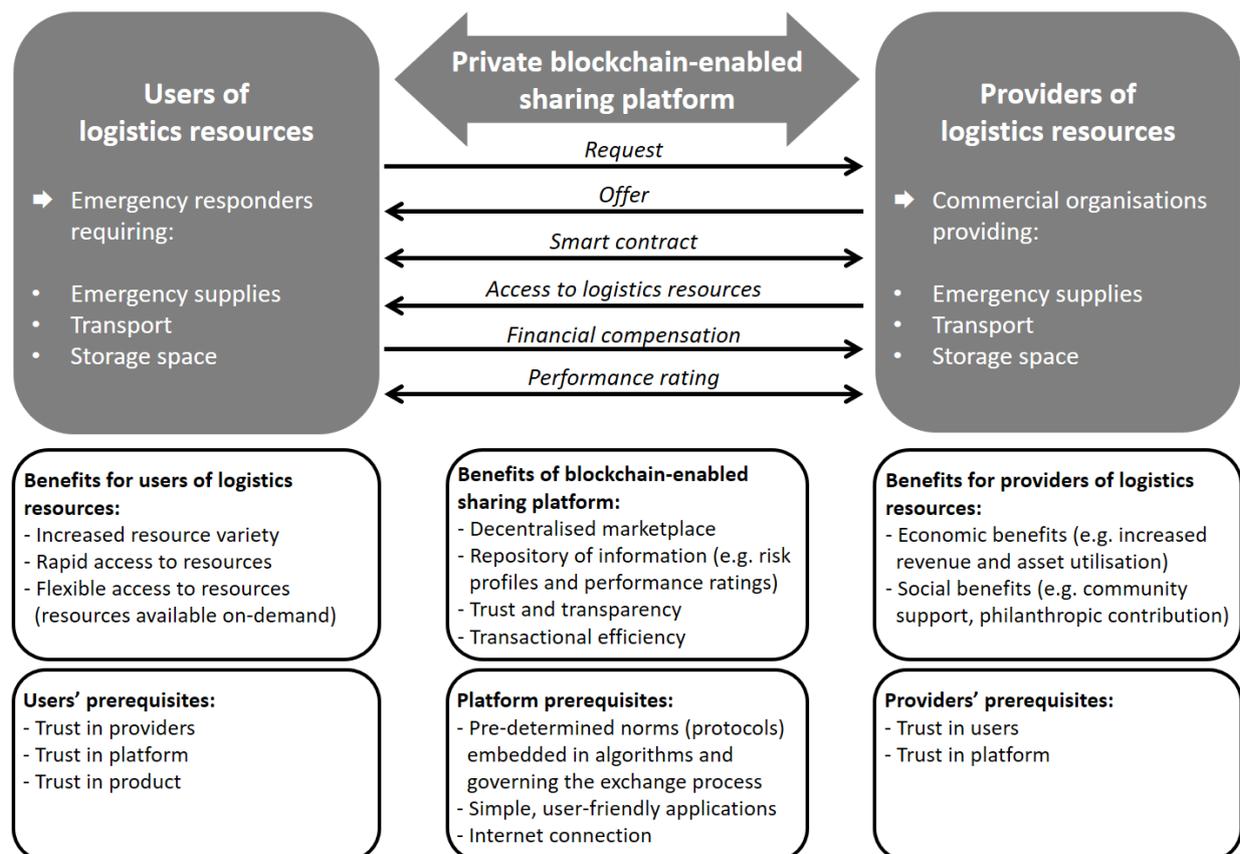
Similar initiatives can be found in New Zealand where Airbnb partnered with Auckland Council in 2016 to provide temporary accommodation support to those affected by a disaster in the Auckland region (Airbnb, 2016). More recently, Airbnb signed a similar agreement with the Ministry of Civil Defence, the lead agency for disaster management in New Zealand, in

order to supplement existing emergency accommodation arrangements and facilitate the nationwide access to free-of-charge temporary accommodation in the aftermath of a disaster (MCDEM, 2018). These initiatives clearly show the relevance of sharing economy platforms to emergency responses.

Blockchain-enabled framework for sharing logistics resources in emergency operations

Bringing the above theoretical insights, academic literature and practical examples together, this section develops a conceptual framework for sharing logistics resources in emergency operations, namely a blockchain-enabled marketplace that connects emergency responders and business organisations. Figure 3 illustrates the proposed framework.

Figure 3. Blockchain-enabled framework for sharing logistics resources in emergency operations



Source: authors.

The marketplace: structure, participants, resources shared and benefits

Referring back to the earlier discussion on the structure of a sharing economy marketplace, the three main elements of the proposed framework are:

1. The users of logistics resources;
2. The providers of logistics resources;
3. The digital platform that brings users and providers together and facilitates their interactions and transactions.

As discussed earlier, the integration of blockchain into the framework enables the users and providers of logistics resources to interact and share resources directly, i.e. independently of any central organisation. For this reason, Figure 3 does not represent any tripartite relationship between the users, the providers and the digital platform (as was the case in Figure 2). Rather, Figure 3 shows that the blockchain-enabled sharing platform supports direct interactions and transactions between the users and the providers of logistics resources.

The users of logistics resources, i.e. the emergency responders, need supplies as well as capacity to transport and store these items and, ultimately, make them available when and where they are needed by those affected by a disaster. In the proposed framework and as per the earlier definition of the sharing economy, emergency supplies include relief items that can be made available temporarily and returned to the owner after being used. This includes, among other things, shelter items (e.g. cots, inflatable beds, blankets), equipment (e.g. chainsaws, electricity generators) and medical supplies (e.g. crutches, wheelchairs). Transport resources are the shipping containers, vehicles (e.g. trucks with or without drivers), trains, aircraft, (coastal) ships, barges, etc. needed to move the relief items and/or people. As illustrated by the Kaikoura earthquake that struck the north-eastern part of New Zealand in 2016 and isolated thousands of people due to the immediate closure of major road and rail transport routes, rapid freight movements between transport modes is a critical element of effective emergency responses (L'Hermitte, Wang, and Deakins, 2018). Storage resources include warehouse space for relief items as well as yard and parking facilities for trucks, trailers and containers. These resources support the availability of emergency supplies across multiple locations in and/or close to the disaster-affected areas.

The providers of logistics resources are the commercial organisations willing and able to contribute emergency supplies, transport resources and/or storage capacity to the relief efforts. These commercial organisations can be transporters, logistics companies, retailers, construction companies, heavy equipment manufacturers, leasing and rental companies, and

any other business organisation with available resources. Transporters include transport companies across all modes, namely road, rail, air and sea (including coastal shipping). Retailers are another key business player in disaster relief due to their local presence (in or near the disaster-affected areas), their sophisticated logistics processes, their extensive transport, storage and distribution networks, as well as their ability to provide and deliver urgently needed supplies at short notice (Swanson and Smith, 2013; Walmart, 2017; White, 2010).

As mentioned earlier when discussing SET and the benefits of exchange interactions, organisations consider their advantage when entering exchange interactions. Typically, business organisations take part in the relief efforts because they want to generate revenue, build strong connections with those affected (customers, broader community, etc.), enhance their corporate image, because they feel that they have a moral duty to participate, and/or have unique resources and core competencies to contribute (Kapucu, 2016; Swanson and Smith, 2013). Referring back to SET, these benefits are either economic (e.g. generating revenue, increasing asset utilisation) or social (e.g. supporting communities through the crisis and making a philanthropic contribution). For the users of logistics resources, the benefits are increased resource variety, resources being available more rapidly, and a more flexible access to capacity (since resources are available on-demand).

Enhancing trust and transactional efficiency in the marketplace

As highlighted by SET and the literature on the sharing economy, trust is a key element in all exchange processes. Since users are expected to engage with providers with which they may not have had any prior interaction, trust has been integrated into the framework illustrated in Figure 3 in the form of a prerequisite to entering an exchange transaction. Drawing on the previously mentioned model developed by Hawlitschek et al. (2016), trust includes two perspectives (users of logistics resources and providers of logistics resources) and three targets (trust in user/provider, in platform and in product). From the perspective of the users of logistics resources, trust includes:

- Trust in provider (the belief that the providers of logistics resources have the skills and experience required to fulfil their obligations, e.g. meet their transport/storage obligations);
- Trust in platform (the belief that the digital platform deploys appropriate algorithms that enable reliable matches, support efficient transactions and enforce the pre-determined rules and contractual agreements);

- Trust in product (the belief that the emergency supplies and logistics services provided will respond to the needs of the users, e.g. fit-for-purpose generators, clean and secure storage space, well-maintained trucks, etc.).

From the perspective of the providers of logistics resources, trust includes:

- Trust in user (the belief that the users of logistics resources will take care of the product, e.g. the shelter items made available to accommodate people in evacuation centres or the trucks provided to transport relief items);
- Trust in platform (the belief that the platform deploys reliable algorithms and ensures secure payments for the logistics resources made available).

In line with our earlier discussion on the intersection between blockchain and the sharing economy, using blockchain changes the sharing economy by supporting direct interactions and transactions (independently of any central organisation acting as a mediator) and by moving from a relationship-based trust system to the creation of digital trust (Möhlmann, Teubner, and Graul, 2019). More specifically, the proposed framework creates a system where trust is not based on positive past experiences between emergency responders and commercial organisations but digitally built. In the proposed framework, trust is enhanced in different ways. Firstly, trust in user/provider and trust in product are the result of the blockchain technology's ability to store and disseminate critical information about network participants, including risk profiles. For example, for transport operations, risk profiles may include information about the history of the transporter's fleet, safety records, as well as details about the transporter's compliance with regulatory and insurance requirements for trucks and drivers (Fuller, 2017). Making this information available on the sharing platform reduces risk perceptions and enhances trust.

Secondly, a system of performance rating is used to provide independent signals, i.e. information about the past performance of the network participants. Accumulated ratings enable organisations to build social capital and to establish trust between unknown service users and providers (Möhlmann et al., 2019). It is proposed that both the users and providers of logistics services should be given the opportunity to rate their transaction partners as soon as the operation has been completed. However, performance ratings should be kept short and simple to enable a rapid rating process. For example, for transport operations, performance ratings may include speed (e.g. travel time), reliability (e.g. on-time pickup), and safety/security (e.g. undamaged delivery).

Thirdly, to avoid contracts to be awarded to inexperienced and/or unreliable organisations and, ultimately, to increase trust in user/provider as well as trust in product, a private blockchain system is proposed. Also called permissioned blockchain, a private blockchain system is managed by a trusted party and supports controlled access to known participants (Ko and Verity, 2016; Vyas et al., 2019). In such a system, only vetted organisations (emergency responders, trusted transporters, authorised retailers, etc.) are granted permission to access the system and use it. Adding an access control layer to the blockchain system provides an additional level of trust and helps facilitate social exchanges between unknown partners. This point will be further developed in the next section that provides details about the management of the blockchain system.

Fourthly, blockchain enhances trust in platform (and transactional efficiency) by matching requests with appropriate resources and by automatically managing and monitoring the steps of the transaction. For example, in the case of a transport transaction, blockchain is first used to enter a request (e.g. specific transport capacity needed to move goods from A to B). The request is communicated to all network participants that can react with specific offers. Based on pre-programmed algorithms, the system automatically selects the offer that best matches the request (e.g. trucks with the right capacity, with the appropriate loading docks, deployable when required, with good safety records, etc.), confirms the transaction by establishing a smart contract, and automates payment as soon as pre-determined conditions have been met (Rohr, 2017). For example, the smart contract can allow for a pre-agreed amount to be paid to the transporter as soon as evidence shows that the items have been loaded onto the truck and for the remainder of the payment to occur upon arrival of the goods at destination (Fuller, 2017). The steps of this transport transaction can be tracked by all interested parties through the blockchain ledger that provides accurate, immutable, time-stamped and digitally verified records (Ko and Verity, 2016).

Finally, trust in the blockchain platform is established by developing and deploying clear and explicit rules and norms (i.e. protocols) governing the transactions between the providers and users of logistics resources. By the same token and as previously discussed, SET states that norms are necessary to regulate the exchange process and facilitate transactions. Therefore, norms are included in the proposed framework as a prerequisite for the blockchain-enabled sharing platform to operate. In order to enhance the network participants' trust in the platform, norms need to be consensually agreed on and understood, and unambiguously clarify the respective duties and obligations of the users and providers of logistics resources. They also need to be sufficiently detailed to cover all aspects of the various transactions, including the

details of the operation, the information and evidence to be provided, the particulars of the payment, etc. Then, these norms need to be embedded in the system's algorithms and in the smart contract codes to enhance transactional efficiency, i.e. speed up and streamline the exchange process.

Like in any sector, the use of blockchain in disaster relief comes not only with advantages, but also with challenges. One of them is the technical and complicated nature of the blockchain technology, including the complexity (and for many the incomprehensibility) of the underlying algorithms. As a consequence, many believe that technical skills are critical to use the technology (Hawlitschek et al., 2018). To overcome this issue, simple and user-friendly applications need to be developed (Ko and Verity, 2016). Another challenge is the fact that the blockchain technology cannot be used without a working communication infrastructure. In other words, blockchain requires an Internet connection which is not always available in the wake of a major disaster (Ko and Verity, 2016; Zwitter and Boisse-Despiaux, 2018).

Overall, this section shows that emergency management can leverage the sharing economy model and the blockchain technology to create new ways of operating in the aftermath of a disaster and to enable responders to work more closely with the private sector. In particular, the framework presented in this section has the potential to support rapid interactions and transactions between emergency responders and business organisations, to enable a broader and more flexible access to logistics resources, to reduce the complexity associated with negotiating and writing contracts for the exchange of these resources, and to reduce the risk of error. All this, ultimately, improves the mobilisation and the deployment of relief items in the aftermath of a disaster.

Managing the blockchain system

The above-mentioned private blockchain system should be managed by the government-mandated emergency management authority in each country, e.g. FEMA in the United States or the Ministry of Civil Defence and Emergency Management (MCDEM) in New Zealand. National emergency management authorities are responsible for providing leadership in emergency operations, for supporting the development of disaster management structures and systems, and for facilitating the cooperation across organisations participating in the relief operations (Webb and McEntire, 2014). They are, therefore, best suited to manage the blockchain system. Taking the lead does not mean acting as an intermediary (as previously mentioned, blockchain supports disintermediation and direct transactions between participants). Rather, the role of emergency management authorities is limited to making the system available

and controlling the access to trusted participants in the country (reputed transporters, logistics service providers, heavy equipment manufacturers, retailers, etc.). In countries where the capacity and the skills necessary to manage the blockchain system are not available, an international organisation (e.g. WFP, recognised for its expertise in the field of humanitarian logistics and already lead of the Logistics Cluster) should manage the system in close collaboration with the national emergency management authorities (since they are able to identify trusted participants).

The purpose of the framework presented in Figure 3 is not to replace the disaster relief systems in place in disaster-prone countries. Rather, the blockchain-based marketplace is seen as an additional tool facilitating communication, coordination and transactions between emergency responders and commercial organisations willing and able to contribute to the relief efforts. Ultimately, it seeks to improve the access to logistics capacity and to remedy some of the inefficiencies commonly observed in emergency operations, including the lack and under-utilisation of logistics resources.

In addition, the proposed framework is not a mandatory system, but a voluntary coordination mechanism supporting the pooling and sharing of supplies, transport capacity and storage space, and facilitating the access to these resources. It should be pre-established prior to the disaster occurrence in order to be fully operational during the disaster relief operations and to speed up the mobilisation of logistics resources. In particular, the identification, evaluation and approval of both the users and providers of logistics services should be completed by the emergency management authority during the disaster preparedness phase. That said, the proposed system should remain a flexible and dynamic tool allowing participants to be included in the network at any time before and after the disaster occurrence as long as these organisations have been approved by the emergency management authority (in order to enhance trust, as explained in the previous section).

In order to operate properly and increase the chances of successful matches, the proposed marketplace requires the highest possible participation of both providers and users of logistics resources. This ‘critical mass’ is necessary to create a network effect and generate sufficient supply and demand (Evans and Schmalensee, 2010) for logistics resources. The proposed marketplace being a voluntary system, organisations are not bound to participate, which reflects the practices used by other humanitarian coordination mechanisms such as the UN Cluster approach. The non-participation in the marketplace is expected to affect the performance of relief supply chains as follows: overlaps and duplications might not be efficiently addressed, emergency responders might lose opportunities to access additional

logistics resources, commercial organisations might miss out on additional revenue sources, and the system might not reach the above-mentioned critical mass. To avoid these negative impacts and attract as many participants as possible, the emergency management authority in charge of operating the system should engage with the interested parties, clearly communicate the benefits of participation, ensure that the digital platform is attractive and easily accessible, support ongoing information exchange and transparency, enhance transactional efficiency, and take all necessary steps to see that participants are appropriately vetted and that trust is built (Hagiu and Rothman, 2016).

Contribution, limitations and further research

Since responding to a major disaster goes beyond the capacity of a single organisation, inter-organisational collaboration is essential in relief operations and emergency responders need to work more closely with other actors, including the private sector. This paper explores how this can be achieved by applying the sharing economy model to disaster relief. Its main contribution is the development of a blockchain-enabled framework for sharing logistics resources in emergency operations. With this framework, this paper presents a new way of interacting and of accessing and deploying logistics resources in emergency operations. It also creates a more integrated and collaborative ecosystem by enhancing the participation of commercial organisations in the relief efforts. Instead of being ad hoc suppliers, commercial organisations become active actors in disaster responses. Therefore, the proposed framework has the potential to transform emergency operations and, ultimately, make a real impact on future relief responses.

However, since this paper is conceptual in nature, the research and its actual value need to be empirically validated. Rather than presenting a final and static framework, this study seeks to stimulate debate within both the academia and the disaster relief sector about the use of the sharing economy model and blockchain. More specifically, the framework presented in the previous section can be used by both researchers and practitioners for further analysing the structure, benefits and prerequisites of a logistics sharing system in emergency responses. To guide future empirical and theoretical investigations, a six-point research agenda is proposed.

Firstly, qualitative empirical research can be conducted to refine and complete the structure of the framework presented in this paper. This includes going into the details of the logistics resources to be shared in disaster relief operations and establishing which types of business organisations should be integrated into the framework. The norms governing the exchange of the different logistics resources also need to be developed. In addition, since the focus of this

paper is on the relationships between emergency responders and commercial organisations, future research can extend the proposed framework to additional actors, including military forces and community centres. Creating a decentralised blockchain-based marketplace enabling the multiple emergency relief agencies (e.g. governmental and non-governmental organisations) to pool and share their resources is an additional avenue for further investigations. Doing so would reduce overlaps and contentions between responders that often compete for the same logistics resources in field operations.

Secondly, qualitative research into the motivations and challenges of the various network participants would be valuable and provide insights into what would make them use (or not) a logistics sharing system in disaster relief operations. Given the large variety of the parties involved in the proposed framework (responders, transporters, retailers, heavy equipment manufacturers, etc.), understanding the perspectives, needs, constraints, and concerns of each of them is essential.

Thirdly, the concept of inter-organisational trust in emergency operations needs to be further investigated. Qualitative empirical research can be used to explore the role and mechanisms of trust and, in particular, the three perspectives mentioned earlier: trust in user/provider, in platform and in product. A thorough understanding of what is required to establish these forms of trust could, in a second phase, support quantitative research and the measurement of the impact of trust on the responders' and commercial organisations' intention to use a logistics sharing system in emergency responses. Doing so would extend the theoretical scope of SET.

The fourth research avenue relates to the value of blockchain in logistics relief operations. While this paper shows that it has potential in the sharing economy and in disaster responses, blockchain is still an immature technology and, despite the hype, the development of real-life blockchain-based applications remains at an early stage (Notheisen, Hawlitschek, and Weinhardt, 2017). Therefore, additional research on the benefits and challenges of using blockchain for sharing logistics resources in emergency responses is needed. This could include applied research with inputs from both practitioners and computer scientists.

Fifthly, this paper provides a foundation for experimental research and the development of a blockchain system bringing the providers and users of logistics resources together on a single platform and streamlining their exchange transactions. Therefore, further research is needed in the form of a pilot project. This pilot project can be trialled by using existing experimental prototypes of blockchain in other fields of study such as energy markets. For example, blockchain was used to test and administer a distributed electricity marketplace integrated into the existing market structures (Li and Nair, 2018, 2019a, 2019b). In any case, a pilot project

should be conducted in partnership with a national emergency management agency (e.g. FEMA in the United States or MCDEM in New Zealand) in order to integrate the insights of emergency practitioners and the practical aspects, constraints and key requirements of their logistics operations into the implementation of a blockchain network.

Finally, the value of using blockchain and sharing logistics resources needs to be considered in different disaster contexts. When emergency management agencies (e.g. FEMA in the United States) have the capacity to respond to disasters using their own resources, relief operations involve domestic actors only. However, when national authorities consider that the disaster is beyond their capacity to respond and call for international assistance, international humanitarian organisations are involved in the relief process. Both contexts should be investigated.

Conclusion

This paper builds on theoretical insights, the academic literature and practical examples to develop a new framework designed to facilitate the involvement of commercial organisations and the sharing of logistics resources in emergency operations. Logistics resources include emergency supplies (e.g. power generators, shelter items such as cots and blankets), transport (across all modes) and storage space. The three main elements of the proposed framework are:

1. The users of logistics resources, namely the organisations in charge of the emergency responses;
2. The providers of logistics resources, namely a variety of commercial organisations willing and able to contribute resources to the relief efforts;
3. A digital interface that connects users and suppliers and facilitates their transactions.

It is argued that the framework presented in this paper integrates and disseminates timely information about the logistics resources available, and facilitates the access to the resources needed in the aftermath of a disaster. It also has the potential to enhance transactional efficiency and operational flexibility.

A central element in the proposed framework is the concept of trust. Trust covers different aspects, including the belief that the users/providers of logistics resources will fulfil their obligations, that the sharing platform has the ability to facilitate efficient, secure and reliable transactions, and that the product underlying the transaction is as expected. Blockchain can be

used to create trust between organisations that do not know each other and/or have never worked with each other.

This paper presents a new way of interacting and accessing logistics resources in emergency operations. It shows that the sharing economy has the potential to change emergency responses by leveraging the resources of commercial organisations. Ultimately, this paper aims to reflect on the mobilisation and deployment of relief items in disaster environments and ensure that they are available when and where they are needed by the affected communities.

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