Available online at www.sciencedirect.com

ScienceDirect

IFAC PapersOnLine 52-13 (2019) 12–17

Leveraging Partnerships with Logistics Service Providers in Humanitarian Supply Chains by Blockchain-based Smart Contracts

Hossein Baharmand * **Tina Comes** **

* *Department of ICT, University of Agder, 4879 Grimstad, Norway (e-mail: hossein.baharmand@uia.no).*

** *Faculty Technology, Policy & Management, TU Delft, Netherlands Department of ICT, University of Agder, 4879 Grimstad, Norway (e-mail: t.comes@tudelft.nl)*

Abstract: As humanitarian organizations are struggling to reach an increasing number of beneficiaries, humanitarian–business partnerships, such as the use of logistics service providers (LSPs), promise to improve effectivity and efficiency of humanitarian assistance. Blockchain-based smart contracts which ensure automation, transparency, and efficiency promise to facilitate partnerships, particularly if trust is low. In this paper, blockchain-based smart contracts are critically examined for their application to humanitarian supply chains (HSCs). We identify various adoption barriers which we categorize into organizational, technological, and environmental. As the use of blockchain-based smart contracts in HSCs is in its early stages, we propose future research propositions and directions that can provide insights into overcoming barriers and challenges of adopting the technology in the humanitarian sector.

Keywords: Blockchain, Humanitarian supply chain, Smart contracts, Partnerships, Logistics service providers.

1. INTRODUCTION

Disasters left more than 130 million people in need of humanitarian assistance in 2018 (GHA, 2018). To help saving the lives of these people and alleviating their suffering, humanitarian supply chains (HSCs) play a critical role. The use of logistics service providers (LSPs) can improve effectiveness and efficiency of HSCs (Baharmand et al., 2017). LSPs typically provide specialized logistics services such as transportation and warehousing, or organization and responsibility for implementation. In recent years, LSPs have become important players in humanitarian operations, providing specialized support for NGOs and governments when they respond to major disasters (Vega and Roussat, 2015).

However, a lack of trust, transparency, and accountability present obstacles for partnerships between Humanitarian Organizations (HOs) and LSPs (Nurmala et al., 2018; Bealt et al., 2016). For instance, observations from the 2015 Nepal earthquake showed that local LSPs were reluctant to sign contracts with small/medium-size HOs , but preferred to cooperate with large HOs that had a better reputation (Baharmand et al., 2017). In turn, HOs experienced problems with LSPs refusing to transport relief items to remote areas due to risks, or with deviations from agreed shipment conditions (Baharmand et al., 2017).

Some researchers have attributed these challenges to a lack of clear, robust and reliable contracts that are suitable for humanitarian–business partnerships (McLachlin and Larson, 2011; Nurmala et al., 2018). One solution to this problem may be blockchain-based smart contracts. Smart contracts are computer protocols that facilitate, verify, and enforce the performance or negotiation of a contract (Buterin et al., 2014). In the context of a blockchain, they are automated and self-executing in a distributed network, meaning that transactions cannot be manipulated, and many aspects of contract execution could be automated. For instance, smart contracts could be used to tie funding to agreed rules or triggers.

While there are some early pilots with blockchain-based smart contracts in HSCs, the outcomes have been rarely systematically discussed. One of the first blockchain-based smart contract pilots involved the United Nations International Children's Emergency Fund (UNICEF) testing 'Ethereum-based smart contracts as a tool for improved efficiency, transparency, and accountability' (UNICEF, 2017) (Aug. 2017- Aug. 2018). Yet, there is no scientifically grounded evaluation that shows in how far UNICEF achieved its objectives. In addition, it is also unclear if a full-fledged implementation is possible given the well-known scalability issue of blockchains.

Because of this lacking rigorous evaluation or framework, there is no systematic understanding of the feasibility of blockchain-based smart contracts in the humanitarian sector (Zwitter and Boisse-Despiaux, 2018). This gap motivates our research questions:*(1) How can blockchain-based*

2405-8963
Peer review under responsibility of International Federation of Automatic Control.
10.1016/j.ifacol.2019.11.084

smart contracts contribute to humanitarian operations? and *(2) what are the barriers to the use of blockchain-based smart contracts in the humanitarian sector?* In this paper, we make a headway in identifying the organizational, technological and environmental requirements of blockchain-based smart contracts. Similar requirements have been developed in the business sector recently (for instance Saberi et al. (2018)), the humanitarian sector has its own principles, standards and requirements. We use the example of smart contracts for partnerships between HOs and LSPs as starting point and derive a research agenda with perspectives on theory building.

This paper is organized as follows. The background regarding the partnership barriers in HSCs and the potential of smart contracts is described in Section 2. In Section 3, the barriers for the implementation of blockchain-based smart contracts are reviewed and categorized into organizational, technological and environmental. Research directions and propositions are discussed in Section 4. Section 5 concludes the paper.

2. BACKGROUND

2.1 Partnership in HSCs

Several scholars argue that collaboration between humanitarian and business sector will improve the efficiency and effectiveness of HSCs by facilitating the transfer of resources, knowledge, skills and expertise (McLachlin and Larson, 2011; Bealt et al., 2016; Nurmala et al., 2017).

Literature has found several motivation factors in humanitarian sector for engaging in partnerships with the business and vice versa. Some scholars argue that such collaboration will improve the efficiency and effectiveness of HSCs by facilitating the transfer of resources, knowledge, skills and expertise (McLachlin and Larson, 2011; Bealt et al., 2016; Nurmala et al., 2017). For HOs, partnerships with business sector can help learning about best practices for addressing resource- and budgetary issues as commercial supply chains have long been recognized as mature supply chains (Nurmala et al., 2017). Furthermore, HOs often face pressure from donors to collaborate with the business sector to be more efficient, visible, accountable, and transparent; to deliver value for money; and to utilize clear performance metrics in HSCs (Charles et al., 2010). For the business sector, partnerships with humanitarians can increase impact and visibility of corporate social responsibility programs (Bealt et al., 2016), which may ultimately help to attract more customers (McLachlin and Larson, 2011).

However, partnerships between the business and humanitarian sector are not widespread (Baharmand et al., 2017; Nurmala et al., 2018). Research has identified some critical challenges for effective humanitarian-business partnerships: first, goals and mandates are different between the two sectors (Jahre, 2017). Second, HOs lack the level of communication and information sharing found in the business sector and are behind in terms of resource management (Nurmala et al., 2017). Third, performance measurement systems have not been effectively developed in HSCs and thus, metrics remain ambiguous (Laguna-Salvadó et al., 2018). Fourth, humanitarian operations often suffer from a lack of transparency and accountability, and the uncertain and varying contexts in which disasters occur (Nurmala et al., 2018; Comes et al., 2018). While these phenomena are known, analyzing how these barriers can be overcome has too often been left as a future research direction in the humanitarian literature (for instance Baharmand et al. (2017)).

2.2 Smart contracts & Blockchain

The concept of a smart contract defined as "a computerized transaction protocol that executes the terms of a contract" (Szabo, 1994) is not new, yet it received substantially more attention with the rise of blockchain technology. In essence, a smart contract is an encoded agreement between two parties that executes an exchange automatically. As such, smart contracts can eliminate the need for intermediaries or trusted authorities, which typically increase the costs or time of transactions (Governatori et al., 2018). The system is schematically presented in Figure 1. By integrating sensors (e.g., through Internet of Things) automation of logistics processes can be supported such as warehousing, delivery reports, and inventory.

In recent years, smart contracts have become more popular because they can be stored and executed on a blockchain (Nachiappan et al., 2015). Blockchain is a shared, distributed ledger on which transactions are digitally recorded and linked so that they provide the entire history or provenance of an asset. A transaction is added to the blockchain only after it has been validated using a consensus protocol. Each record is encrypted to provide an extra layer of security.

One crucial benefit of blockchain-based smart contracts is transaction transparency (Zwitter and Boisse-Despiaux, 2018). Because smart contracts are created and managed on a blockchain, the transaction record is available and (theoretically) immutable. This eliminates ambiguities that may exist in paper trails. Regulators can also review transaction records during audits (Governatori et al., 2018). Blockchain-based smart contracts, therefore, are particularly promising in complex contexts with multiple actors where lack of trust can hinder collaborations.

Very few HOs, such as UNICEF, have tried to explore the potential of smart contracts through pilots based on Ethereum (UNICEF, 2017). Ethereum is a blockchain-based general purpose distributed computing platform, which uses smart contract functionality. It employs the Ethereum Virtual Machine and Solidity to execute peer-to-peer agreements. Once terms are agreed upon, both assets are in place, they are tokenized, and exchanged by a process called an atomic swap where the trade is the settlement (Ethereum, 2016).

Examples like the UNICEF's pilot are the first explorations into the blockchain-based smart contract technology in the humanitarian sector. Yet, it is unclear what consequences of using the technology are (Zwitter and Boisse-Despiaux, 2018). Some recent studies highlight concerns regarding blockchain applications such as 'hype-without-evidence and suggest a critical study of challenges (Burg et al., 2018; Coppi and Fast, 2019).

Fig. 1. HO and LSP collaboration without (left) and with (right) blockchain-based smart contracts

3. BLOCKCHAIN-BASED SMART CONTRACTS IN HSC – UNDERSTANDING THE BARRIERS

In this section, we systematically analyze the concerns related to blockchain-based smart contracts in the humanitarian sector. We use the technology, organization, and environment (TOE) framework (Tornatzky et al., 1990) as it has been widely used in studies on IT adoption (Oliveira and Martins, 2011). The barriers in each category were determined based on the literature related to intra/inter-organizational information systems, cross-sector partnerships and blockchain technology in humanitarian contexts. We communicated the list of barriers with two experts from UNICEF and WFP (two HOs who have recently explored blockchain pilots) and their feedback was used for validation.

3.1 Organizational context

We identify three barriers in this category related to financial slacks, top management support, and organizational compatibility. First, adopting blockchain technology requires a substantial investment of resources for preparations, training, implementation, and monitoring. Resources, however, are often very limited in HOs. According to GHA (2018), less than %70 of appeals for humanitarian assistance were funded in 2018 which can mean that HOs struggle with budget issues. Furthermore, there is pressure from donors to spend monetary resources on assisting those in-need, and justifying technology development is challenging unless there is direct impact on humanitarian objectives (Jahre, 2017).

Second, adopting the technology without support from higher management is not possible. Although few HOs have dedicated innovation departments, the path for innovation management in several HOs is unclear (Vaisanen, 2017). Indeed, the hesitation to adopt (new) information systems has been noted in several studies (for instance Van de Walle and Comes (2015)). Although some argue that the humanitarian sector should not be a testbed (Sandvik et al., 2014), the strengths and weaknesses of innovative solutions cannot be explored without pilots.

Third, smart contracts require critical changes in contracting processes and performance metrics (Zwitter and Boisse-Despiaux, 2018; Chen, 2018). The technology therefore requires dedicated capacity and support for changing organizational culture, processes/procedures, and tools. Research shows that key organizational factors to technology adoption are centralization of decision-making; and interpersonal networks within an organization. Networks are positively related to adoption while centralization is negatively related (Russell and Hoag, 2004). As such, technology adoption and policy changes are notoriously difficult in the humanitarian sector, which is characterized by centralized management structures and a high turnover of staff.

3.2 Technological context

We note four main barriers in this category related to readiness, complexity, infrastructure, and compatibility. First, the blockchain technology is still immature in terms of security and scalability (Chen, 2018). Once a smart contract is created and hosted on the blockchain, everything about it will be automated. However, the code is written by programmers; the potential for human error is thus not eliminated, and contracts may contain mistakes. While some solutions have been suggested to mitigate blockchain security challenges, the effectiveness of these solutions has not been evaluated (Governatori et al., 2018). With respect to scalability, increasing size and number of blocks is a storage dilemma for handling big data in real-time (Nachiappan et al., 2015). Therefore, improvements in storage management and advanced cloud computing will be required.

Second, the requirements of blockchain-based smart contracts can make them cumbersome. The contract requires that all eventualities and possible outcomes are thought through and agreed upon upfront, which is difficult in highly dynamic situations. Some argue that a smart contract is at best an 'offer' because the ability to adapt and negotiate is not included (Saberi et al., 2018).

Third, using blockchain technology requires access to the Internet; areas with inadequate infrastructure or capacity are not be appropriate. Moreover, the technology is relatively new, intricate and difficult to be integrated in current HOs' systems (Chen, 2018).

Fourth, the immutability feature of blockchain technology, i.e., information can only be changed in blockchain upon consensus, can cause compatibility challenges. Immutability prevents falsifying and adulteration of data however,

there is still the possibility of having erroneous data. Even if the owners can edit data and update it, the scar of erroneous record will always be in the blockchain (Zwitter and Boisse-Despiaux, 2018).

3.3 Environmental context

This category involves three barriers which relate to legislation, the extent of adoption among other HOs, and humanitarian-business partnerships. First, smart contracts, much like a variety of blockchain-based technologies, are not yet comprehensively regulated (Governatori et al., 2018). The social, legal and regulatory frameworks, including applicable privacy norms, for blockchain are developing at a relatively slow pace. The future of those who rely on such contracts is thus subject to significant uncertainty in regulations and policy.

Second, the use of blockchain and smart contracts are not widespread in the humanitarian sector. Although very few pilots have been initiated Chen (2018), advantages and disadvantages of different designs are not yet fully understood. Moving forward will require a rigorous assessment combined with well-selected implementation choices.

Third, organizational mandates, strategic objectives and working culture differ between the humanitarian and business sectors (Nurmala et al., 2017). While HOs' mandate is saving lives, the business sector strives for profit. Furthermore, the strategic objective of HOs relates to cost reduction, capital reduction and service improvement. However, these objectives in the business sector are defined based on the financial returns delivered to shareholders. HOs can be wary of working with the business sector because they need to be seen as independent and impartial (Nurmala et al., 2018). At the same time, business corporations can be wary of working with the humanitarian sector because they perceive it to lack capabilities and professionalism (Bealt et al., 2016). This can limit partnerships with businesses to explore incentives and develop solutions based on blockchain.

4. DISCUSSION – RESEARCH AGENDA ON ADOPTION AND DIFFUSION

Despite recent interests on using blockchain in the humanitarian sector, there are but few efforts to explore the potential of technology and its barriers (Coppi and Fast, 2019). Building on our findings related to benefits and barriers to adopt blockchain-based smart contracts in HSCs, we next consider theoretical and research implications by developing four research propositions based on our review and discussions with experts.

The first proposition relates to the capability of blockchain-based smart contracts to facilitate trading in a low-trust environment. Blockchains are developed to minimize the amount of trust required from any single actor in a system by distributing trust among different actors in the system with pre-defined rules (Nachiappan et al., 2015). Transactions can, for instance, be verified by the majority of HSC actors, who define the consensus rules, and there is less need for building trust between to LSPs.

Such a trustless system could dramatically change buyer–supplier relationships and challenge the related trust theories such as transaction costs economics (TCE). TCE has been widely used in management due to its value for explaining organizational decisions (Ireland and Webb, 2007). In the HSC management, TCE has been recognized as one of the most commonly applied theories (Tabaklar et al., 2015). Taking a trustless environment into consideration, HSC management theory needs to be reevaluated. Thus, our first research proposition is defined as:

P1 Blockchain-based smart contract facilitates partnership in a trustless environment, such as ad-hoc collaborations in disasters. This concept is likely to transform the current trust-based theories in HSC literature.

The second proposition concerns the automation capability of blockchain-based smart contracts. Most prominently, the Internet of Things (IoT) can play a role in effective partnerships by making monitoring easier. Information gathered from IoT-connected devices can be transmitted to the blockchain and trigger events coded in a smart contract. Real-time information in SCs, especially removing multiple middle layers (as on a blockchain platform), facilitates HSC risk management (Jahre, 2017). There are also other opportunities like coupling forecast-based financing with smart contracts. Regulations, contracts, and policies, that may delay SC and logistic activities, can automatically be executed. Thus, the combination will not only increase efficiency of funding but also reduce the response time and thus, improve the effectiveness of HSC. However, as the humanitarian sector is increasingly looking to private enterprise and academia to develop and deliver blockchain-based solutions, there is a dearth of evidence that validates the impact of such initiatives.

P2 Combining blockchain-based smart contracts with existing or emerging information and communication technologies leads to more integrative practices such as information sharing or coordination, improving supply chain performance. This needs to be empirically validated.

Third, we identified a number of barriers but it is not clear, which are the most critical. Humanitarian actors operate in environments that are intrinsically dynamic and unstable and that diverge from the private sector, in which the blockchain technology has been designed. Furthermore, the failure rates of business–driven technologies are often high in the disaster contexts (Chen, 2018). One critical concern is that areas with limited or non-existent internet access risk becoming an impediment part of the system. That said, further investigation about the potential impact of barriers facilitates making informed decisions regarding whether to use the technology in HSCs or not.

P3 Prioritizing barriers to adopting blockchain-based smart contracts can contribute to more informed decision making regarding if and in which contexts to use technology.

Fourth, although blockchain-based smart contracts may offer great opportunities, they can also present a number of ethical challenges and dilemmas. According to Sandvik et al. (2014), the question of how technological innovation affects humanitarian assistance needs more critical inquiry.

Multiple researchers (for instance Meier (2011)) show that HOs have experienced situations where technology creates dependencies that, when disrupted, have aggravated the crisis situation. To address such challenges and support the development of blockchain-based smart contracts in HSCs, interdisciplinary investigations are needed to build theories and designs for the technology.

P4 Concerns and issues related to the longer-term impact of technology in HSCs have to be also investigated through interdisciplinary research.

5. CONCLUSIONS

Despite an increasing interest in using blockchains in the humanitarian sector, barriers and challenges have not yet been explored rigorously. Reports show that there is a concern of 'hype-without-evidence among scholars and practitioners (Coppi and Fast, 2019). In our paper, we make a headway in systematically analyzing the concerns related to diffusion and adoption of blockchain-based smart contracts in the humanitarian sector. To this end, we proposed and discussed the potential of blockchain-based smart contract to leverage partnerships with LSPs in HSCs.

The technology can increase time or cost efficiency while improving transparency. However, there are barriers of adopting the technology in HSCs which we categorized into organizational, technological, and environmental contexts. In the organizational, we found (1) constrained monetary resources, (2) insufficient support and commitment from management, and (3) the need for critical changes in processes as the three main barriers. In the technological, the four main obstacles were (1) the immaturity of the technology, (2) its cumbersome requirements, (3) inadequate infrastructure in disasters, and (4) the immutability of the transactions. In the environmental, the barriers included (1) regulation problems, (2) few pilots in the sector, (3) different mandates, principles and objectives with related negative perceptions between HOs and commercial partners.

Building on the above, we suggested the following research agenda: (i) realizing shifts in trust-based theories in HSCs; (ii) investigating the impact of using blockchain-based smart contracts empirically; (iii) prioritizing adoption barriers through further analysis; (iv) analyzing longer-term impact through interdisciplinary research.

Our paper thus makes two contributions. First, to the best of our knowledge, this study is the first attempt to identify and categorize the barriers of adopting blockchain-based smart contracts for HSCs which also validates the barriers with experts who have been involved in pilot projects. Second, our research agenda contributes to better understanding the impact of the technology on humanitarian operations and related theories. Thereby, we aim to inform technology design, development and testing.

ACKNOWLEDGEMENTS

We thank experts from UNICEF and UN WFP who helped us with their comments about the benefits and barriers.

REFERENCES

Baharmand, H., Comes, T., and Lauras, M. (2017). Managing in-country transportation risks in humanitarian supply chains by logistics service providers: Insights from the 2015 nepal earthquake. *International journal of disaster risk reduction*, 24, 549–559.

Bealt, J., Fernández Barrera, J.C., and Mansouri, S.A. (2016). Collaborative relationships between logistics service providers and humanitarian organizations during disaster relief operations. *Journal of Humanitarian Logistics and Supply Chain Management*, 6(2), 118–144.

Burg, J., Murphy, C., and Petraud, J. (2018). Blockchain for international development: using a learning agenda to address knowledge gaps. *MerlTech. URL: http://www.merltech.org/blockchain-for-international-development-using-a-learning-agenda-to-address-knowledge-gaps/ Accessed March*, 27, 2019.

Buterin, V. et al. (2014). A next-generation smart contract and decentralized application platform. *white paper*.

Charles, A., Lauras, M., and Tomasini, R. (2010). Collaboration networks involving humanitarian organisations–particular problems for a particular sector. In *Working Conference on Virtual Enterprises*, 157–165. Springer.

Chen, C. (2018). New trends in humanitarian assistance–blockchain for humanitarian aid: Problem or panacea?

Comes, T., Bergtora Sandvik, K., and Van de Walle, B. (2018). Cold chains, interrupted: The use of technology and information for decisions that keep humanitarian vaccines cool. *Journal of Humanitarian Logistics and Supply Chain Management*, 8(1), 49–69.

Coppi, G. and Fast, L. (2019). Blockchain and distributed ledger technologies in the humanitarian sector. Technical report, HPG Commissioned Report.

Ethereum (2016). Ethereum project. *What is Ethereum? URL: https://www.ethereum.org. Accessed December*, 27, 2018.

GHA (2018). Global humanitarian assistance (gha) report 2018. *London: Global Humanitarian Assistance. URL: http://www. globalhumanitarianassistance.org/reports. Accessed October*, 27, 2018.

Governatori, G., Idelberger, F., Milosevic, Z., Riveret, R., Sartor, G., and Xu, X. (2018). On legal contracts, imperative and declarative smart contracts, and blockchain systems. *Artificial Intelligence and Law*, 26(4), 377–409.

Ireland, R.D. and Webb, J.W. (2007). A multi-theoretic perspective on trust and power in strategic supply chains. *Journal of Operations management*, 25(2), 482–497.

Jahre, M. (2017). Humanitarian supply chain strategies–a review of how actors mitigate supply chain risks. *Journal of Humanitarian Logistics and Supply Chain Management*, 7(2), 82–101.

Laguna-Salvadó, L., Lauras, M., Okongwu, U., and Comes, T. (2018). A multicriteria master planning dss for a sustainable humanitarian supply chain. *Annals of Operations Research*, 1–41.

McLachlin, R. and Larson, P.D. (2011). Building humanitarian supply chain relationships: lessons from leading practitioners. *Journal of Humanitarian Logistics and Supply Chain Management*, 1(1), 32–49.

Meier, P. (2011). New information technologies and their impact on the humanitarian sector. *International review of the Red Cross*, 93(884), 1239–1263.

Nachiappan, M.C., Pattanayak, P., Verma, S., and Kalyanaraman, V. (2015). Blockchain technology: beyond bitcoin. *Sutardja Center for Entrepreneurship&Technology*.

Nurmala, N., de Leeuw, S., and Dullaert, W. (2017). Humanitarian–business partnerships in managing humanitarian logistics. *Supply Chain Management: An International Journal*, 22(1), 82–94.

Nurmala, N., de Vries, J., and de Leeuw, S. (2018). Cross-sector humanitarian–business partnerships in managing humanitarian logistics: an empirical verification. *International Journal of Production Research*, 1–17.

Oliveira, T. and Martins, M.F. (2011). Literature review of information technology adoption models at firm level. *Electronic Journal of Information Systems Evaluation*, 14(1), 110.

Russell, D.M. and Hoag, A.M. (2004). People and information technology in the supply chain: Social and organizational influences on adoption. *International Journal of Physical Distribution & Logistics Management*, 34(2), 102–122.

Saberi, S., Kouhizadeh, M., Sarkis, J., and Shen, L. (2018). Blockchain technology and its relationships to sustainable supply chain management. *International Journal of Production Research*, 1–19.

Sandvik, K.B., Jumbert, M.G., Karlsrud, J., and Kaufmann, M. (2014). Humanitarian technology: a critical research agenda. *International Review of the Red Cross*, 96(893), 219–242.

Szabo, N. (1994). Smart contracts. *Unpublished manuscript*.

Tabaklar, T., Halldórsson, Á., Kovács, G., and Spens, K. (2015). Borrowing theories in humanitarian supply chain management. *Journal of Humanitarian Logistics and Supply Chain Management*, 5(3), 281–299.

Tornatzky, L.G., Fleischer, M., and Chakrabarti, A. (1990). The processes of technological innovation. issues in organization and management series. *Lexington Books. Available at http://www. amazon. com/Processes-Technological-Innovation-Organization/Management/dp/0669203483. Accessed June*, 10, 2013.

UNICEF (2017). Unicef ventures: Exploring smart contracts. *UNICEF Stories of Innovaion. URL: http://unicefstories.org/2017/08/04/unicef-ventures-exploring-smart-contracts/. Accessed December*, 27, 2018.

Vaisanen, S.P. (2017). Managing disruptive innovation in the risk-averse humanitarian sector: applying blockchain technology to the cash-based transfers: initial results from world food programme's building blocks-project.

Van de Walle, B. and Comes, T. (2015). On the nature of information management in complex and natural disasters. *Procedia Engineering*, 107, 403–411.

Vega, D. and Roussat, C. (2015). Humanitarian logistics: The role of logistics service providers. *International Journal of Physical Distribution & Logistics Management*, 45(4), 352–375.

Zwitter, A. and Boisse-Despiaux, M. (2018). Blockchain for humanitarian action and development aid. *Journal of International Humanitarian Action*, 3(1), 16. doi:10.1186/s41018-018-0044-5. URL `https://doi.org/10.1186/s41018-018-0044-5`.