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ORIGINAL PAPER

APPLICATIONS OF PERFORMANCE INDICATORS FOR OPTIMIZATION OF HUMANITARIAN CHAINS

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ABSTRACT. Background: Humanitarian operations are a key contribution to alleviating human suffering and reducing property damage. The success of these measures is conditioned by the implementation of efficient and sufficiently flexible logistics chains. The specificity of the conditions for the distribution of material aid requires the preparation of a suitable distribution system, the necessary capacities, and the creation of conditions to achieve the flexibility of individual solutions. The key issue for the implementation of the humanitarian aid distribution itself is the identification of suitable performance indicators, considering the specifics in the individual phases of humanitarian aid implementation.
Methods: The approach is based on the research and content analysis, followed by creating a conceptual model and workflow diagram using interviews with experts, and identifying key performance indicators for optimization within the case study.
Results: The humanitarian supply process was identified through a workflow diagram. A model was built to illustrate a case study of the use of rail transport to the provide humanitarian aid to Ukraine crisis in 2022. Performance indicators are compiled for the model. Recommendations are formulated for the creation of suitable indicators of the performance of humanitarian logistics chains.
Conclusion: A gap and research problem in performance improvement and its measurement is identified within humanitarian logistics. This study examines the opportunity to improve the performance of humanitarian distribution to Ukraine in 2021.

Keywords: Humanitarian logistics, optimization of humanitarian chains, key performance indicators

INTRODUCTION

In recent years, there has been an increasing number of incidents requiring a response from humanitarian supply chains (HSCs). Academic interest has also increased in the last 15 years and humanitarian logistics is becoming an independent research discipline. This is coupled with an increase in interest from the commercial sector and a political inclination to engage in humanitarian operations. Humanitarian organisations (HO) are receiving more financial sources, and their capabilities are increasing. As capacities expand, interest increases in improving the efficiency of humanitarian aid delivery.

The specificity of the conditions for the distribution of material aid requires the preparation of a suitable distribution system, the capacities, and the creation of conditions to achieve the flexibility of solutions. The key issue for the implementation of the humanitarian aid distribution itself is the identification of suitable performance indicators, considering the specifics of the humanitarian sector.

This paper deals with the development of a conceptual model of humanitarian aid distribution and explores options for applying key performance indicators (KPIs). Subsequent optimization is based on a case study based on data from a HOs.

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CONDITIONS FOR DISTRIBUTION IN THE HUMANITARIAN SECTOR

In practice, several constraints affect the effectiveness of the distribution of humanitarian aid. This issue is described comprehensively in the literature [Kovács & Spens, 2011]. However, the research area is relatively young compared to the commercial sector. Based on keywords, 200 articles and conference papers dealing with the performance of humanitarian supply chains can be searched in the leading databases Web of Science (WOS) and Scopus [Repík and Foltin, 2022a]. This is countered by Thomas and Kopczak's [2005] prediction that disaster death rates will increase over the next 50 years.

The conditions that affect the performance of HSC are rooted in the main differences between the humanitarian and commercial sectors. HSCs typically operate under uncertainty and time pressure. Several logistical complications are often encountered in humanitarian deliveries (e.g., destroyed or disrupted infrastructure, the need to obtain storage space and personnel, or means of transport and handling). An infrastructure problem usually has two possible scenarios:

- the constraint improves over time (e.g., high winds);
- or the constraint expands with time (e.g., war or floods).

Given the chaotic environment, an analogy for HSCs can be found in military supply chains [Repík and Foltin, 2022b]. Researchers have identified several challenges facing HSCs in trying to measure and improve performance. As the main problems, Sawhill and Williamson [2001] identified difficulty and cost in linking HO's annual efforts to the reflection of those efforts on the organisation's mission. Van der Laan et al. [2009] discovered data accuracy problems and that performance indicators are not geared toward future improvement. Similarly, Abidi et al. [2014] found that it is challenging to link the performance of HSC to their objectives. Schiffling and Piecyk [2014] described the influence of different stakeholders who each define objectives differently, which causes problems in defining milestones.

In the case of the HO for our case study, several additional conditions that affect performance were defined and that may not apply to other HOs. One of the main shortcomings is human resources (HR), which is due to the organisation's volunteer structure. HR affects many aspects from data collection in the field to the ability to sustain long-term workload [Repík and Foltin, 2022a]. Especially the data collection problem is a significant limitation in subsequent optimization attempts [Tulach and Foltin, 2019]. Another specificity is the lack of funding, which is largely dependent on public interest and media attention [Schiffling and Piecyk, 2014; Repík and Foltin, 2022a]. The problem is also the variability of events. In the last 3 years alone we have seen floods, tornadoes, pandemics, and a war accompanied by a massive refugee wave on the territory of the Czech Republic [Repík and Foltin, 2022a].

Based on the above, insufficient coordination between individual actors in humanitarian aid and entities providing distribution services in affected regions was identified as the main research gap. From the point of view of the urgency of the required humanitarian aid, the uncertain and uncertain conditions of the distribution of this aid, there is a requirement for synchronized optimization of individual transport and distribution services, including the subsequent processes of humanitarian logistics.

OBJECTIVES AND METHODS

The purpose of the research is to identify the possible approaches to optimize the available humanitarian aid distribution capacities and their effective use in phase delivery.

RQ: What are the key workflow aspects of HSC and their optimization possibilities through KPI and conceptual modelling?

The primary aim of the paper was identified as the necessity to develop a conceptual model of humanitarian transport to Ukraine using freight trains and to investigate KPIs by which the performance can be measured in further research. The first step is a detailed description from a

process-oriented and object-oriented perspective.

Our approach is based on the research and content analysis, followed by creating a conceptual model and identifying KPIs for subsequent optimization within the case study. Data were collected and the model was built in collaboration with the Czech Red Cross (CRC). The model was drawn using the diagrams.net platform and model was converted into Simio software.

IDENTIFICATION OF PERFORMANCE INDICATORS IN THE AID DELIVERY PHASE

Researchers have developed several approaches over the last 20 years. Among the most well-known is the use of methods that are commonly used in the commercial sector, e.g., the Balanced Scorecard (BSC) by Kaplan and Norton [1992], the Supply Chain Operations Reference (SCOR) model by Supply Chain Council [2010], or modifications thereof [Abidi et al., 2014]. Researchers also use a variety of modern tools, e.g. Mukhopadhyay and Roy [2016] discussed the use of Radio-Frequency Identification (RFID) to increase the efficiency of HSCs. However, emerging technologies have not yet been seen much in the sector. This is related to the limited budgets and skills of HOs. However, based on data from the WOS and Scopus databases, the use of modelling and simulations is no longer unknown (see Figure 1).

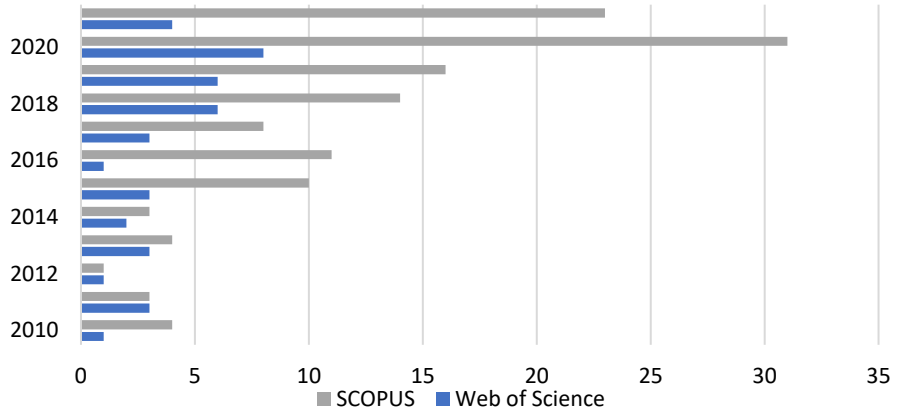

Fig. 1. Number of publications on humanitarian supply chains combined with modelling and simulations between 2010 and 2021
Source: [own]

Setting performance indicators is problematic due to differences between operations, long-term and short-term interventions, and the pre-disaster and post-disaster phases [Repík and Foltin, 2022a]. Therefore, there is a need to investigate indicators that are general enough to be generalisable. However, there is the trap of over-generalisation.

At this point, logistics in the aid delivery phase was separated from the improvement of the HSC as a whole. There are several reasons why it is relevant. Van Wassenhove [2006] states that nearly 60-80 % of the costs incurred in humanitarian operations are due to logistics activities. Balcik [2017] notes that effective logistics management is a key objective in the management of HSC. For logistics performance monitoring, we suggest the use of indicators:

- response time;
- lead time;
- percentage of successful deliveries;
- use of transport capacity in reverse flow;
- logistic cost.

The use of transport capacity in reverse flow can be challenging to meet. However, this indicator is related to the European Commission's (EC) assistance efforts in Ukraine [European Commission, 2022]. It is possible to use reverse flow material, e.g. in the form of packaging and waste, or use of the commercial sector requirements for exports from Ukraine.

The last option brings additional benefits, e.g., support of the Ukraine's economic recovery.

CASE STUDY

Intense fighting broke out in Ukraine on 24 February 2022. As a result, millions of people have been in need, and a refugee crisis has emerged. Our study focuses on supplies to meet the huge and urgent needs in Ukraine. Overall, 92,5 tons of humanitarian aid worth more than EUR 2 300 000 were transported by the CRC during the reviewed period (see Table 1). All of the material was based on active demand. However, there was the problem of low demand for train transport in each order. The items were transported during 23 missions.

Table 1. List of transport materials

Specification		**Weight (kg)**
Medical material	trauma sets	5029
	surgical material	6640
	medicines and disinfectants	3723
	medical supplies	15110
	rescue tents	1180
	medical backpacks	200
	external fixators	1320
	transport aids	1058
	gurneys	4050
	other	6043
Food & water		30854
Drugstore goods		8977
Emergency equipment		4930
Electronics		2126
Other		1216

Overall		
Boxes	560	pcs
Pallets	264	pcs
Tons of material	92.456	t
Worth of material (CZK)	58 334 517.92	CZK
Worth of material (EUR)	2 330 944.55	EUR
Number of cars used	32	pcs
Number of kilometres travelled	40532	km

Source: (Czech Red Cross data)

Data based on road transport can be used for comparison in the simulation software to see how train transport performs compared to road transport. The maximum allowed train length in the Czech Republic is 720 m and the maximum weight can be set at 25 t per wagon of 27 wagons [Pohl and Michálek, 2018]. The length varies with infrastructure capacity and legislation in different countries. Based on research by Allianz pro-Schiene [2006], up to 89% of freight trains in Germany in 2006 were less than 700 meters long. Therefore, we count on a train length of 600 meters when demand is high.

CONCEPTUAL MODEL

In cooperation with the CRC and other partners, a visualised HSC for train transport is highlighted in Figure 3. In the next step, we transferred the model to Simio (see Figure 2). This is relevant for further research, where we will explore scenarios through simulations. The main reasons we based our model with train transport mode can be found in economic, environmental, and geopolitical aspects. As concerns individual means of transports, e.g. to switch from road to rail transport is in accordance with the European Commission, for example the European Commission [2021]. The savings of train transport compared to road transport are about EUR 30 000 per consolidated train. The price of fuel is rising, and the EU is trying to reduce its dependence on Russia. Train transport is less environmentally impactful. However, there are disadvantages, e.g. the need for large volumes of freight, or the different track gauges.

We designed a workflow diagram (see Figure 4). In the context of humanitarian aid, there are several possible scenarios for the flow of information and materials, among the most common are:

1. demand side requests goods and transport;
2. demand side requests only transport;
3. HO offers goods and transport;
4. private actors offer goods (and/or transport) through a HO, which offers to the demand side.

We place importance on active demand. In practice, it is often the case that humanitarian situations are targeted for political and commercial marketing purposes. This principle corresponds to Schiffling's and Piecyk's [2014] customer-oriented approach. It is also needed to check the inquiry for items that are against humanitarian principles (e.g. military material), or special authorisation requirements (e.g. the Regulation on the International Carriage of Dangerous Goods by Rail (RID)). Failure to meet demand is usually based on the fact that these entities are against the principles of a HO.

In the transportation phase, we need to evaluate the different alternatives based on cost, risk, and speed for the maximization of 7Rs.

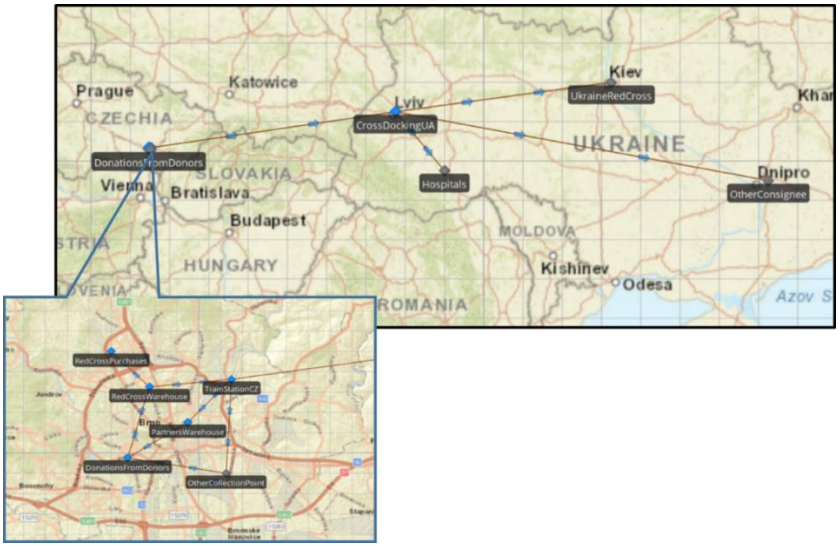

Fig. 2. Model of the supply chain in Simio
Source: (own)

DISCUSSION OF RESULTS

The research goal was the identification of possible approaches, which could contribute to increasing of the overall capabilities of the humanitarian aid, through the application of KPI and conceptual modelling. On the basis of the Ukrainian humanitarian case study, the conceptual model was developed. This model could be considered as a base for further optimization steps of the HSC. Measuring and improving HSC performance has long been a research gap. This problem was already identified by Blecken [2010]. On the basis of our investigation, it can be confirmed as a constant occurrence in our HO. Behl and Dutta [2019] identified a number of studies that examine the performance of HSC. However, there is still a problem with empirical validation. Kunz and Reiner [2012] state that HOs cannot fully control the performance of HSC. However, the performance of systems can be improved by improving the performance of its parts.

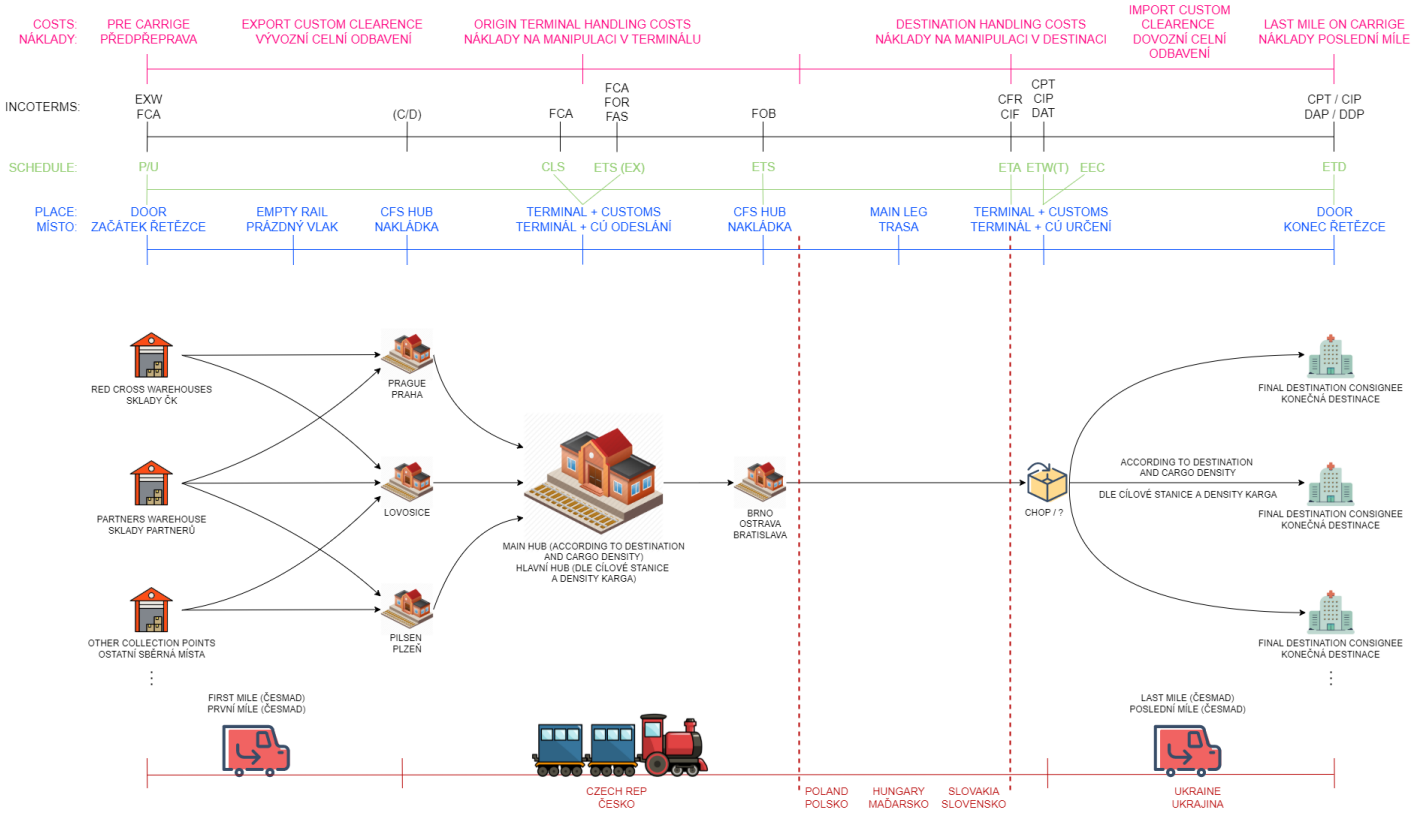

Fig. 3. Model of the supply chain

Source: (own)

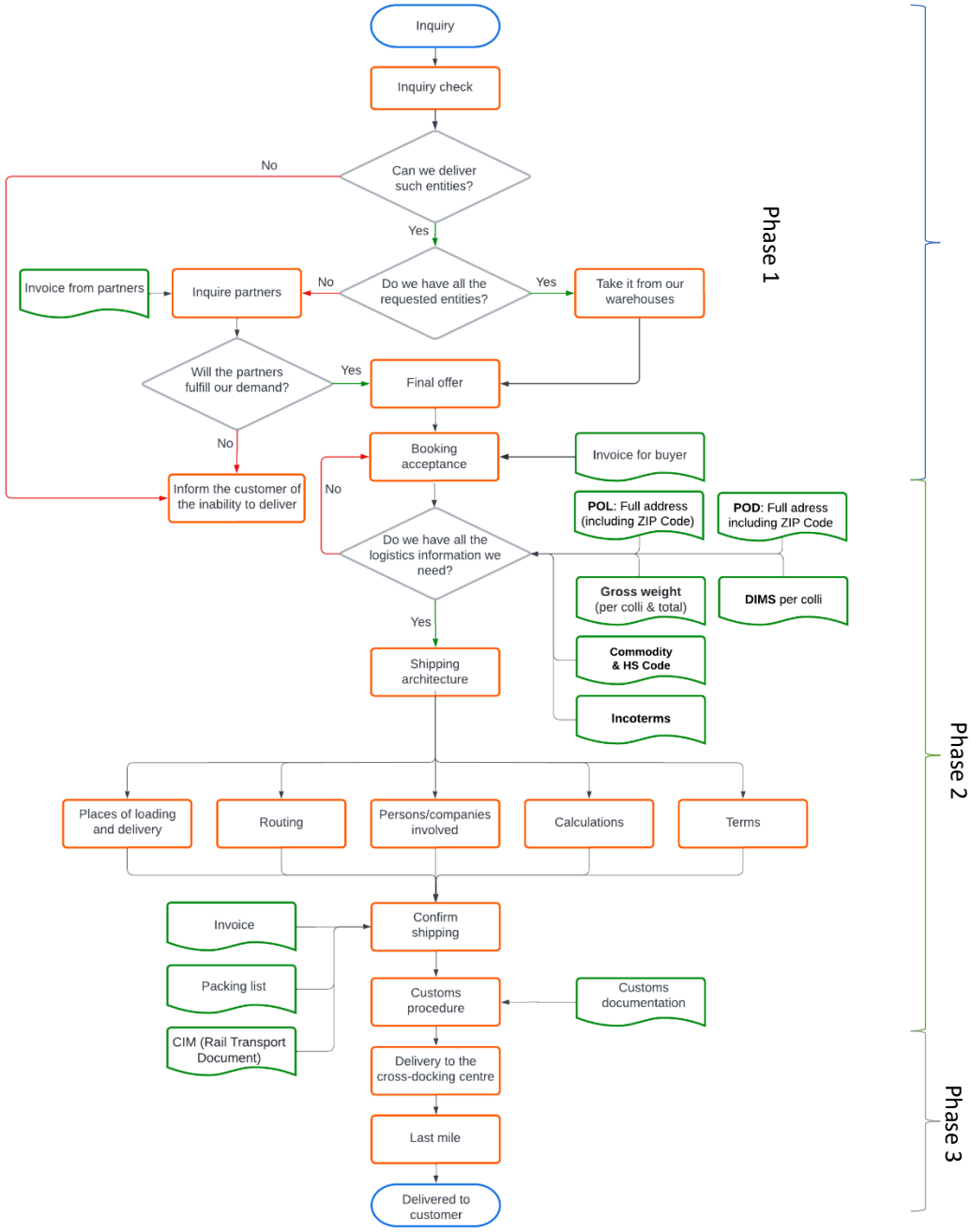

Fig. 4. Workflow diagram for the delivery of humanitarian aid

Source: (own)

The research question is answered through the outcome of the conceptual modelling and created workflow diagram. As an important step, the synchronization of workflows with other partners in affected areas and the synchronization on the main transportation network infrastructure were identified. Dubey et al. [2020] confirm that information sharing and collaboration in humanitarian operations increase the agility of the HSC. Within the conceptual model, three main phases of preparation and implementation of humanitarian aid were identified. Based on the generalization of the prepared research, the overall distribution process could be divided into a three-phase functional algorithm for the distribution of humanitarian aid. We build the model to be considered generally useable for

various types of humanitarian operations. This should be further validated in practice and research.

As a research limitation, the availability of suitable data sources could be considered. This corresponds to the overall uncertainty which is characteristic for all humanitarian operations

For further research, it is recommended to develop the conceptual model within the modelling/simulation environment for the dynamic discrete event, e.g. Simio software, which allows us to use the agent approach at the same time. Based on a review article, Anjomshoae et al. [2022] summarize that simulations are a useful tool for HSC performance management. Our data show an increasing trend in the number of articles dealing with simulations in HSC. The crucial element for these next steps will be data farming and its availability and validity. Van der Laan et al. [2009] identified data as a big problem for the HSC back in 2009. This problem is still relevant. For example, Sigala et al. [2020] are looking for a solution in ERP systems for HSC, but this is still a distant solution in our HO.

CONCLUSION

The provision of humanitarian assistance is an increasing concern with the increasing number and variability of adverse events. Today, society is becoming aware of the need to address social aspects of human activities. On the basis of the research results, humanitarian aid must be treated with a certain degree of rationality within the whole supply chain.

The conceptual model is based on a real case study and develops a proposal for the distribution of humanitarian aid. In this specific case, rail transport was found to be the most economically advantageous mode of transport for ensuring the transport and distribution of humanitarian aid. Rail transport is more cost-effective over long distances than road transport. This is exactly the situation that may arise when Ukraine's post-conflict reconstruction phase begins. The situation will be characterised by the long distance and the large amount of cargo to be transported.

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REFERENCES

Abidi, H., de Leeuw, S., Klumpp, M., 2014. Humanitarian supply chain performance management: a systematic literature review. Supply Chain Management: An International Journal 19, 592–608. https://doi.org/10.1108/SCM-09-2013-0349

Allianz pro Schiene, 2006. Überblick: Wie der Güterzug länger werden kann [Overview: How the freight train can become longer.]. https://www.allianz-pro-schiene.de/themen/aktuell/740-meter-gueterzug/ (accessed 7.10.22).

Anjomshoae, A., Banomyong, R., Mohammed, F. and Kunz, N., 2022. A systematic review of humanitarian supply chains performance measurement literature from 2007 to 2021. *International Journal of Disaster Risk Reduction*. duben 2022. Vol. 72, 102852. https://doi.org/10.1016/j.ijdrr.2022.102852.

Balcik, B., 2017. Site selection and vehicle routing for post-disaster rapid needs assessment. Transportation Research Part E: Logistics and Transportation Review 101, 30–58. https://doi.org/10.1016/j.tre.2017.01.002

Behl, A. and Dutta, P., 2019. Humanitarian supply chain management: a thematic literature review and future directions of research. *Annals of Operations Research*. prosinec 2019. Vol. 283, no. 1–2, 1001–1044. https://doi.org/10.1007/s10479-018-2806-2

Blecken, A., 2010. Supply chain process modelling for humanitarian organizations. TATHAM, Peter a PETTIT, Stephen (ed.), *International Journal of Physical Distribution & Logistics Management*. 1 leden 2010. Vol. 40, no. 8/9, 675–692. https://doi.org/10.1108/09600031011079328

Dubey, R., Bryde, D. J., Foropon, C., Graham, G., Giannakis, M. and Mishra, D. B., 2020. Agility in humanitarian supply chain: an organizational information processing perspective and relational view. *Annals of Operations Research*. online. 23 říjen 2020. [Viděno 9 říjen 2022]. https://doi.org/10.1007/s10479-020-03824-0

European Commission, 2022. Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions: An action plan for EU-Ukraine Solidarity Lanes to facilitate Ukraine's agricultural export and bilateral trade with the EU.

European Commission, 2021. New transport proposals target greater efficiency and more sustainable travel.

Falagara Sigala, I., Kettinger, W. J. and Wakolbinger, T., 2020. Digitizing the field: designing ERP systems for Triple-A humanitarian supply chains. *Journal of Humanitarian Logistics and Supply Chain Management*. 16 březen 2020. Vol. 10, no. 2, 231–260. https://doi.org/10.1108/JHLSCM-08-2019-0049

Kaplan, R., Norton, D., 1992. The Balanced Scorecard: measures that drive performance. Harvard business review 70, 71–79.

Kovács, G. & Spens, K. M., 2011. Trends and developments in humanitarian logistics - a gap analysis. International Journal of Physical Distribution and Logistics Management, 41(1), 32-45. https://doi.org/10.1108/09600031111101411

Kunz, N. and Reiner, G., 2012. A meta-analysis of humanitarian logistics research. *Journal of Humanitarian Logistics and Supply Chain Management*. 19 říjen 2012. Vol. 2, no. 2, 116–147. https://doi.org/10.1108/20426741211260723

Mukhopadhyay, J., Roy, S., 2016. Managing Disaster Supply Chains with RFID for Humanitarian Logistics, in: Sahay, B.S., Gupta, S., Menon, V.C. (Eds.), Managing Humanitarian Logistics. Springer Int Publishing Ag, Cham, 115–127. https://doi.org/10.1007/978-81-322-2416-7_8

Pohl, J., Michálek, T., 2018. Provoz nákladních vlaků délky 740 m [Operation of freight trains with a length of 740 m], díl I. Vědeckotechnický sborník ČD 2018, 21.

Repík, D., Foltin, P., 2022a. Measuring The Performance of Humanitarian Supply Chains and Problems of Their Application In Practice, in: 39th IBIMA Conference Proceedings. Presented at the 39th IBIMA International Conference, IBIMA publishing, Granada.

Repík, D., Foltin, P., 2022b. Vliv sektorové inflace na humanitární dodavatelské řetězce [Effect of sectoral inflation on humanitarian supply chains], in: 16th PhD Student Conference New Approaches to the State Security Assurance. Presented at the 16th PhD Student Conference New Approaches to the State Security Assurance, University of Defence in Brno, Brno, p. 8.

Sawhill, J.C., Williamson, D., 2001. Mission Impossible?: Measuring Success in Nonprofit Organizations. Nonprofit Management Leadership 11, 371–386. https://doi.org/10.1002/nml.11309

Schiffling, S., Piecyk, M., 2014. Performance measurement in humanitarian logistics: a customer-oriented approach. Journal of Humanitarian Logistics and Supply Chain Management 4, 198–221. https://doi.org/10.1108/JHLSCM-08-2013-0027

Supply Chain Council, 2010. SCOR Model. https://scor.ascm.org/processes/introduction (accessed 7.12.22).

Thomas, A.S., Kopczak, L., 2005. From Logistics to Supply Chain Management: The Path Forward in the Humanitarian Sector. Fritz Institute 15, 1–15.

Tulach, P., Foltin, P., 2019. Research Methods in Humanitarian Logistics - Current Approaches and Future trends, in: Proceedings of The 19th International Scientific Conference Business Logistics in Modern Management. Presented at the Business Logistics in Modern Management, University of Osijek, Faculty of Economics, Osijek, 459–474.

Van der Laan, E. a., De Brito, M. p., Vergunst, D. a., 2009. Performance measurement in humanitarian supply chains. International Journal of Risk Assessment and Management 13, 22–45. https://doi.org/10.1504/IJRAM.2009.026388

Van Wassenhove, L.N., 2006. Humanitarian aid logistics: supply chain management in high gear. Journal of the Operational Research Society 57, 475–489. https://doi.org/10.1057/palgrave.jors.2602125

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