Flex Serv Manuf J (2018) 30:363–365
https://doi.org/10.1007/s10696-017-9301-y

EDITORIAL

Green logistics solutions

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Published online: 4 December 2017

Today, climate change is the greatest challenge for future generations. In particular, logistics is perceived as a key sector to contribute to sustainable development meeting the future generations' needs in terms of low greenhouse gas emissions in a socially and economically responsible way. Green logistics involves all attempts to reduce the ecological impact of peoples' mobility, traffic systems and of transport in regional and global supply chains including the reverse flow of products and materials.

The primary objective of this special issue is to reflect the sustainable development of logistics from various perspectives preferably in an integrated and holistic approach and to examine research issues concerned with quantitative analysis and decision support for supply network design, freight transport and

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logistics infrastructure. For this special issue eight papers from 36 submissions have been selected for publication after a thorough peer-review according to the standards of the FSM journal.

1 Papers in the special issue

The first paper by *A. Banasik*, *J. M. Bloemhof-Ruwaard*, *A. Kanellopoulos*, *G. D. H. Claassen,* and *J. G. A. J. van der Vorst* provides a comprehensive literature review on multi-criteria decision making (MCDM) approaches for designing efficient and effective green supply chains. A conceptual framework is proposed to identify relevant publications and to categorize papers with respect to decision problems, indicators, and MCDM approaches. Particularly, the paper aims to review different MCDM approaches which can be used to quantify trade-offs between economic, social, and environmental criteria, i.e. to identify green production options.

The subsequent paper by *M. Mostert*, *A. Caris,* and *S. Limbourg* presents a bi-objective optimization model for intermodal freight network design which considers economic and environmental objectives with three modes of transport: road, intermodal rail, and intermodal inland waterways. As an application example the case of Belgium is examined. Results highlight practical information on how flows, terminal types, and locations vary depending on the chosen policy and on costs and emissions depending on the number and the type of terminals in the network.

The third paper by *P. Rogetzer*, *L. Silbermayr,* and *W. Jammernegg* deals with sustainable sourcing of strategic raw materials by integrating recycled materials. The authors develop a single-period inventory model to derive the order quantities for virgin and recycled raw materials to determine the related costs and evaluate the effectiveness of the sourcing strategy. Managerial insights into the benefits of such a green sourcing approach are provided. This strategy is compared to standard sourcing without recycling. Numerical results show that green sourcing is especially beneficial in terms of cost savings for high demand variability, high prices of virgin raw material and low expected recycling prices.

Freight consolidation in intermodal networks with reloads is the topic of the paper by *W. J. A. van Heeswijk*, *M. R. K. Mes*, *J. M. J. Schutten,* and *W. H. M. Zijm*. A planning algorithm for dynamic pickup and delivery problems in intermodal networks is proposed, where freight is consolidated by means of reloads to reduce both costs and emissions. The algorithm evaluates consolidation opportunities for the best routes by applying a decision tree structure, considering reload operations, timetables, and synchronization of departure windows. Numerical experiments reveal that, compared to direct road transport, significant benefits both in terms of costs and environmental impact can be gained.

The subsequent contribution by *M. Hrušovský*, *E. Demir*, *W. Jammernegg,* and *T. van Woensel* also considers green intermodal transportation network design. The authors present a novel solution framework using a combination of an optimization model and simulation. The simulation model includes stochastic elements in the form of uncertain travel times, whereas the optimization model represents a deterministic and linear multi-commodity service network design formulation. The

proposed approach is implemented to real-life scenarios where differences in transportation plans for alternative objectives such as costs, time, and CO_2e emissions are presented.

In their paper, *W. Chen*, *M. Mes,* and *M. Schutten* investigate a multi-hop driver-parcel matching problem with time windows. With the aim of using spare capacities along the existing transportation flows to deliver small-to-medium freight volumes, this paper proposes a general integer linear programming (ILP) formulation, which incorporates drivers' maximum detour, capacity limits, and the option of transferring parcels between drivers. Due to the high computational complexity, two heuristic solution procedures are developed. The numerical study shows that economic and environmental benefits can be obtained, depending on the spatial characteristics of the network and drivers' schedules.

The paper by *J. Grabenschweiger*, *F. Tricoire,* and *K. F. Doerner* addresses the trade-off between emissions and disturbance in an urban context. They introduce the bi-objective emissions disturbance traveling salesman problem (BEDTSP), which aims at minimizing CO_2 emissions as well as disturbance to urban neighborhoods, when planning the tour of a single vehicle delivering goods to customers. The investigated strategies consider optional nodes, thus allowing detours that yield fewer disturbances, but also possibly more emissions. All models and strategies are compared in an extensive computational study using the city of Vienna, Austria, as a case study.

The final paper by *R. M. Post*, *P. Buijs*, *M. A. J. uit het Broek*, *J. A. Lopez Alvarez*, *N. B. Szirbik,* and *I. F. A. Vis* presents a solution approach for deriving alternative fuel station infrastructure requirements. In this paper, the authors design and apply a new solution approach to establish minimum infrastructure requirements in terms of the number of alternative fuel stations. The effectiveness of the approach is demonstrated by applying it to the case of introducing liquefied natural gas (LNG) as a transportation fuel in The Netherlands. Specific insights are gained on the minimum number of LNG fuel stations necessary to employ LNG trucks economically and environmentally.

2 Concluding remarks

This special issue has greatly benefited from the cooperation among the authors, reviewers, and editors. We would like to express our sincere thanks to the reviewers for their excellent and timely refereeing. Last, but not least, we thank all authors for their contributions which made this special issue possible.