Smart Logistics and The Logistics Operator 4.0

Chiara Cimini[1], Alexandra Lagorio[1], David Romero[2], Sergio Cavalieri[1], Johan Stahre[3]

[1]Department of Management, Information and Production Engineering, University of Bergamo, Italy,
chiara.cimini@unibg.it, alexandra.lagorio@unibg.it, sergio.cavalieri@unibg.it
[2]Tecnológico de Monterrey, Mexico, david.romero.diaz@gmail.com
[3]Chalmers University of Technology, Sweden, johan.stahre@chalmers.se

Abstract: The advent of the Fourth Industrial Revolution is expected to deeply change several aspects of the manufacturing industry. Among them, the logistics and supply chain activities will be affected by these changes both at operational and managerial level to face the market drivers of flexibility and mass-customisation. In this context, the work of operators in internal and external logistics will be affected by these changes and increase the interaction between humans and machines. The evolution of the roles of humans in Logistics 4.0 will give birth to "The Logistics Operator 4.0" paradigm. The aim of this paper is to investigate the impacts of Industry 4.0 technologies on the different roles of logistics operators that work in the main logistics domains and areas.

Keywords: Industry 4.0, Logistics 4.0, Smart Logistics, Operator 4.0, Logistics Operator 4.0.

1. INTRODUCTION

The Industry 4.0 paradigm (or smart manufacturing) is one of the much-addressed research topics since it is supposed to have significant impacts in the way products will be designed, engineering, manufactured, and delivered in the near future (Hofmann & Rüsch, 2017). In today's business world, the market, customer requirements of customisation, flexibility and responsiveness are increasingly pushing manufacturers to extend their *logistics networks* to include and coordinate all the suppliers and optimise internal-external logistics processes as well as fastening decision-making processes (Lasi et al., 2014).

With the broad *Industry 4.0 paradigm,* a specific research stream on the impacts and applications of Industry 4.0 technologies in logistics has been emerging under two different labels: "Smart Logistics" or "Logistics 4.0" (Müller & Voigt, 2018). The "4.0 paradigm" is the result of the increased use of the Internet (of Things, Services and Persons (IoTSP)), which allows real-time communication between products, machines, services and humans, and the use of advanced digital tools. Therefore, *Logistics 4.0* relies on the use of technological applications that allow the effective planning of resources and the efficient management of warehousing and transportation systems to ensure efficiency in transferring data and materials between departments (Barreto et al., 2017).

Providing a general understanding about the *Logistics 4.0* topic, Winkelhaus & Grosse (2019) highlighted its three main aspects: (i) the implications of a new production paradigm (i.e. mass-customisation) for logistics; (ii) the use of new digital technologies (e.g. Internet of Things (IoT) and Cyber-Physical Systems); and (iii) the importance of humans in their roles of employees, customers and stakeholders.

This last point suggests that the human factor in *Logistics 4.0* represents one of the most important topics to deal with in order to support the technological development from a human-centred point of view. Given the variety of roles that humans play in the logistics and supply chain context, in this research, a specific focus is put on the *Logistics Operator 4.0*.

According to the literature, the role of logistics operators in Industry 4.0 can undergo through two main evolutionary paths, which are (i) their replacement by technology, or (ii) their assistance or augmentation by it (Romero et al., 2016a; Cimini et al., 2019). To deep into the investigation about the logistics operator in the Industry 4.0 context, the *Operator 4.0* concept by Romero et al. (2016a) can be used as a reference in order to study the 'physical' and 'cognitive' interactions among the operators and the technology in a smart manufacturing context (Romero et al., 2016b).

In particular, this paper aims at discussing the impacts of Industry 4.0 technologies introduction on different operators that are involved in the logistics activities concerning *internal logistics* (i.e. picking, handling, packaging, and warehousing – inside the factory) and *external logistics* (i.e. supply chains management – outside the factory).

The paper is structured as follows. Section 2 presents a brief literature review and is divided into two subsections, which discuss the Industry 4.0 vision application in logistics and the *Operator 4.0* concept. In Section 3, the *Logistics Operator 4.0* will be discussed. In particular, several technologies will be presented and related to the logistics operators that can make use of them. Several logistics areas are involved and will be discussed also. Section 4 discusses the challenges and research needs in dealing with such evolution. Section 5 concludes the paper with limitations and future research development paths.

2. LITERATURE REVIEW

2.1 Industry 4.0 in Logistics

In literature, it is widely recognised that the new paradigm of Industry 4.0 will bring several opportunities for a significant improvement in different aspects of internal and external logistics, such as efficiency, sustainability or responsiveness to customers (Strandhagen et al., 2017a). The key components of Industry 4.0, in particular, Cyber-Physical Systems (CPSs) and the Industrial Internet of Things (IIoT), can support the real-time tracking and tracing of materials inside and outside the factories, consequently allowing an improved internal and external logistics management (Hofmann & Rüsch, 2017). Indeed, *Logistics 4.0* concerns both, (i) a technical perspective – that relates to the usage of digital tools and technologies for logistics, and (ii) a processual perspective – that deals with the operational activities performed within the logistics processes (Szymańska et al., 2017). To research about the Industry 4.0 technologies applied to logistics, the term *Smart Logistics* has been extensively employed, referring to logistics systems that are flexible and able to adjust according to market changes and customer needs (Barreto et al., 2017).

In order to point out the main applications of new technologies in the logistic field, Strandhagen et al. (2017b) have placed the Industry 4.0 technologies applied to manufacture logistics in four groups:

I.	*Decision-Support and Decision-Making* – refers to the potentials of Artificial Intelligence (AI) and Big Data Analytics to automate decision processes or support human decisions with a data-driven approach;

II.	*Identification and Interconnectivity* – refers to the IIoT and smart sensors technologies able to uniquely identify products and materials, and consequently, improve the tracking and tracing of the products inside and outside the factories;

III.	*Seamless Information Flow* – refers to the IT systems integration (or vertical integration), that leverages also on Cloud Computing, to provide real-time access to data and information from multiple sources, in order to allow a more responsive real-time production planning and scheduling; and

IV.	*Automation, Robots and New Production Technologies* – concern with the introduction of new devices and smart/ intelligent transportation systems able to replace or support the human work in the manual operations.

Thus, Industry 4.0 technologies can actively support logistics both in physical operations that concern, for instance, material handling, warehousing or transportation and in management activities that mainly deal with the resources planning. At the same time, new technologies have potential impacts both on the internal logistics flows (Schmidtke et al., 2018), and on the whole supply chain organisation (Wamba & Akter, 2015), thanks to the possibility to achieve a "horizontal integration" among stakeholders, which improves their visibility and coordination.

However, in any areas of logistics that can benefit from the introduction of technological innovations, some issues arise about the impacts of such technologies on human work (Schmidtke et al., 2018). The research about the evolution of the human role in logistics is of utmost importance and different directions can be envisioned. For this reason, a literature review about the role of operators in Industry 4.0 is a preliminary step to develop this research work and will be discussed in the following subsection.

2.2 Industry 4.0 and The Operator 4.0

The *Operator 4.0* has been defined by Romero et al. (2016a; 2016b) as "a smart and skilled operator who performs not only cooperative work with robots but also work aided by machines as and if needed by means of human cyber-physical systems, advanced human-machine interaction technologies and adaptive automation towards human-automation symbiosis work systems". The *Operator 4.0 vision* explores the newly available technological means for supporting and aiding the physical and cognitive work of the operators in smart manufacturing environments in three possible ways: (i) *Assisted Work* – where the operators are still performing the key tasks and making the key decisions, but a wearable device, a collaborative robot or an AI is executing the repetitive and standardized tasks or decisions on their behalf in order to make their work easier, (ii) *Collaborative Work* – where the operators work side-by-side with collaborative robots (cobots) and AIs, each performing the tasks they are best at and supporting each other, and (iii) *Augmented Work* – where operators use technology (i.e. wearable devices) to extend their 'physical' and 'cognitive' capabilities. Furthermore, the *Operator 4.0 vision* is not in conflict with the usage of *automation* for those dull, dirty and dangerous tasks for the operators (Romero et al., 2016a; 2016b).

3. THE LOGISTICS OPERATOR 4.0

3.1 Towards The Logistics Operator 4.0

As an instantiation of the *Operator 4.0* definition, a *Logistics Operator 4.0* is defined in this paper as "a smart and skilled operator who uses enterprise wearable tech-gadgets and works together with software and hardware social robot companions and helpers in order to make his/her work easier and safer at internal and external logistics environments" (see Fig. 1 & 2).

In smart *internal* logistics environments (i.e. smart shopfloors and smart warehouses), two groups of supporting Industry 4.0 technologies for the *Logistics Operator 4.0* have been defined.

I.	*Material Flows Handling Technologies* – this group is composed of (i) *Exoskeletons* enhancing the human body while lifting and moving heavy objects easier, improving human performance and preventing workplace injuries, (ii) *AGVs* as auxiliary wheeled robots taking over material transport from humans, working autonomously or in conjunction with them to move parts and products by acting as shuttles between humans who pick and humans that assemble parts or pack products; moreover, *AGVs* allow humans to focus on key tasks such as identifying the right part or product on a shelf, picking easily a part or a product in a non-standardized container or package, and understanding the human context of a part or a product in

order to properly position it in a shelf or in a container or pack it for its addressee, (iii) *Drones* eliminating most of the need for humans to climb warehouses racks and perform dangerous work during picking or inventory auditing, and (iv) *Collaborative Robots* helping in pick-n'-place, load-n'-unload, inspection, kitting and packing activities of parts and products. These four supporting technologies relieve humans from repetitive physical work and movement, thus increasing performance and safety simultaneously.

II. *Information Flows Management Technologies* – this group is composed of (i) *Handheld Computers* giving humans access to digital dashboards and relevant information on-the-go in the facility, (ii) *Wearable Scanners* and *Voice-Direct Headsets* saving time in stock-taking and enabling a hands-free worker to do other tasks (e.g. picking, sorting, staging) while still having a scanner at hand, (iii) *Smart Glasses* supporting pick-by-vision, augmented labelling and facility navigation as well as enabling remote video conferencing between workers for collaborative problem-solving, and (iv) *Activity-Trackers* monitoring the activity and performance of workers for a productive and healthier workplace. These four supporting wearable technologies allow a hand-free workforce focusing on the task at hand, reduce human error and contribute to superior ergonomics.

Similarly, in smart *external* logistics environments (i.e. smart supply chains), two groups of supporting Industry 4.0 technologies for the *Logistics Operator 4.0* have been defined.

I. *Material Flows Handling Technologies* – this group is composed of (i) *Smart Cargo-Handling Gears* (i.e. cranes, trucks, forklifts) sharing real-time information about their location, condition and status of an operation for supporting logistics operators in equipment management and control activities (e.g. the identification of bottlenecks and idle equipment, condition-based maintenance strategies), and (ii) *Smart Containers* providing real-time information on their location, position, temperature, humidity, CO2 level, vibration activity, unauthorised door opening and customs status for supporting logistics operators in cargo-handling management activity.

II. *Information Flows Management Technologies* – this group is composed of (i) *Virtual Assistants* supporting logistics operators in standardized tasks such as placing (recurrent) purchase orders, follow-up orders, e-mailing compliance documentation, autogenerating standard reports, providing inventory control alerts and events notification, and handle frequently asked questions, and (ii) *Visual Analytics Tools* enabling logistics operators to interact with data analytics tools to turn data into reliable and provable knowledge by selecting the adequate data analysis, visualisation and interpretation methods according to the need to present the data analysis results in a decision- or task-oriented way.

3.2 Logistics Areas and related Industry 4.0 Technologies for The Logistics Operators 4.0

As mentioned before, *Logistics Operators 4.0* work in smart internal and external logistics environments that belong to different logistic areas: picking, packaging, material handling and storage management to internal logistics, and traceability and logistics flows management to external logistics. Industry 4.0 technologies have spread across different logistics areas.

Grounding on scientific literature analysis, Table 1 reports the most applied 'supporting' and 'enabling' technologies for each logistic area, highlighting the different benefits that can be gained by the *Logistics Operators 4.0,* and the logistics operations, from their adoption.

Moreover, in this paper, we define a *Supporting Technology* as any device or system that acts as (i) a Human-Material Interface (HMI) between the Logistics Operators 4.0 and their material handling systems, supporting their interactions in the handling of material flows, or as (ii) a Human-Computer Interface (HCI) between the Logistics Operators 4.0 and their computer information systems, supporting their interactions in the management of information flows; and an *Enabling Technology* as any information and communication system enabling the interconnection of devices and digital services that connect, exchange and process data in a smart logistics environment.

Table 1 – Logistics Areas & Related Industry 4.0 Technologies for the Logistics Operators 4.0 & Smart Logistics Operations

L	Area	Supporting Technologies	Enabling Technologies	Benefits	Sources
Internal Logistics	Picking	For Material Flows Handling: • Exoskeletons (lifting) • AGVs (picking) • Drones (picking) • Collaborative Robots (picking) For Information Flows Mgmt.: • Handheld Computers (picking orders information) • Wearable Scanners (barcodes, RFID tags) • Voice-Direct Headsets (voice picking) • Smart Glasses (pick-put to light) • Activity Trackers (steps, heart-rate)	For Material Flows Handling: • Smart Fast Rotation Storage Systems • Smart Trasloelevators • Smart Mini-Loaders For Information Flows Mgmt.: • Order Management Systems (OMS) • Inventory Management Systems (IMS) • Picking Route Management Systems (PRMS) • Scheduling Management Systems (SMS)	For the Logistics Operators 4.0: • Less Fatigued Operators • Efficient Labour For Smart Logistics Operations: • Faster Picking • Picking Accuracy • Faster Information Exchange • Reduced Operating Expenses	(Grosse et al., 2015; van Lopik et al., 2019; Wahrmann et al., 2019)

|					
	Packaging	For Material Flows Handling: • Collaborative Robots (inspection, kitting and packing) For Information Flows Mgmt.: • Labelling Systems	For Material Flows Handling: • Industrial Robots (inspection, kitting and packing) For Information Flows Mgmt.: • Order Management Systems (OMS)	For the Logistics Operators 4.0: • Less Fatigued Operators • Fewer Risks for Operators • Efficient Labour For Smart Logistics Operations: • Faster Packaging • Faster Information Exchange • Reduced Operating Expenses	(Wahrmann et al., 2019)
	Storage	For Material Flows Handling: • Exoskeletons (moving) • AGVs (moving) • Drones (moving) Collaborative Robots (load-n'-unload) For Information Flows Mgmt.: • Smart Sensors (beacon tags)	For Material Flows Handling: • Smart Fast Rotation Storage Systems • Smart Trasloelevators • Smart Mini-Loaders For Information Flows Mgmt.: • Inventory Management Systems (IMS)	For the Logistics Operators 4.0: • Less Fatigued Operators • Fewer Risks for Operators • Efficient Labour For Smart Logistics Operations: • Location/Position Accuracy • Less Space Used • Enhanced Inventory Visibility • Just-in-Time Inventory • Faster Information Exchange • Reduced Operating Expenses	(Gong & De Koster, 2008)
	Material Handling	For Material Flows Handling: • Exoskeletons (moving) • AGVs (moving) • Drones (moving) • Collaborative Robots (load-n'-unload) For Information Flows Mgmt.: • Smart Sensors (beacon tags) • Wearable Scanners	For Material Flows Handling: • Auto-ID Technologies (RFID) • Smart Lifts and Forklifts • Wearable Scanners For Information Flows Mgmt.: • Warehouse Management Systems (WMS) • Inventory Resources Planning (IRP)	For the Logistics Operators 4.0: • Less Fatigued Operators • Fewer Risks for Operators • Efficient Labour For Smart Logistics Operations: • Inbound and Outbound Optimisation • Fewer Handling Risks • Reduced Operating Expenses	(Zou & Zhong, 2018)
External Logistics	**Traceability**	For Material Flows Handling: • Smart Containers For Information Flows Mgmt.: • Visual Analytical Tools	For Material Flows Handling: • Auto-ID Technologies (RFID tags) • IoT/IIoT Devices For Information Flows Mgmt.: • Track & Trace Systems • GPS Systems • Blockchain	For the Logistics Operators 4.0: • Visibility • Transparency • Predictability • Adaptability For Smart Logistics Operations: • Better Quality Control • Fewer Security Risks • Real-Time Decision-Making • Faster Information Exchange • Reduced Operating Expenses	(Park & Huh, 2018)
	Logistics Flows & Stocks Management	For Material Flows Handling: • Smart Cargo-Handling Gears • Smart Containers For Information Flows Mgmt.: • Virtual Assistants • Visual Analytical Tools	For Material Flows Handling: • Smart Conveyors For Information Flows Mgmt.: • Warehouse Management Systems (WMS) • Transportation Management Systems (TMS) • Big Data Analytics	For the Logistics Operators 4.0: • Visibility • Transparency • Predictability • Adaptability For Smart Logistics Operations: • Better Quality Control • Integration with the Suppliers • Information Accuracy • Faster Information Exchange • Reduced Operating Expenses • Improved Customer Relations • Improved Supplier Relations	(Grosse et al., 2015)
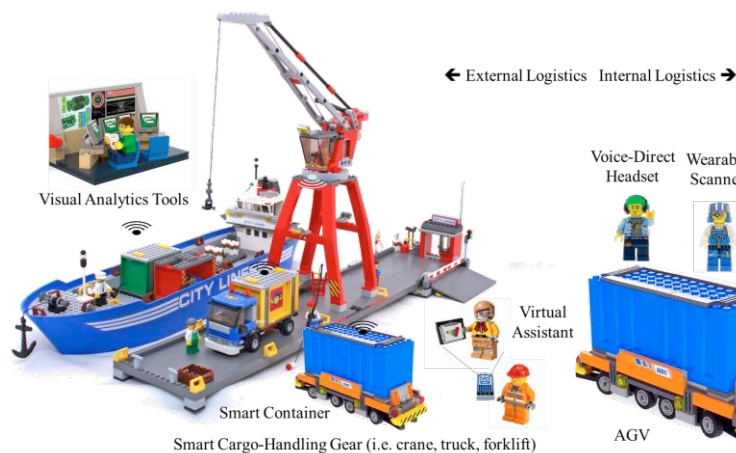
Fig. 1. Overview – Logistics Operator 4.0: External Logistics   Fig. 2. Overview – Logistics Operator 4.0: Internal Logistics

4. CHALLENGES AND RESEARCH AGENDA

According to the previous considerations about the *Logistics Operators 4.0* and their interactions with Industry 4.0 technologies, different research and technical challenges emerge and will need further investigation in the future. In the following paragraphs, they are discussed in relation to the support that logistics operators receive from technology in replacing or assisting some of their tasks. Nevertheless, it is worth mentioning that the challenges in the introduction of new technologies in *Logistics 4.0,* as it occurs for Industry 4.0 in general, always include "socio-technical" aspects. Indeed, alongside the development of new smart technologies, proper developments in the human-related aspects must be carried out both at the theoretical and practical level. For instance, at the theoretical level, it is of utmost importance to highlight the interdependencies between technological implementation and the human capabilities, while, at the practical level, to provide logistics companies with effective methods and tools to drive their workforce towards the new paradigm of *Logistics 4.0,* thus aligning the technological innovations with a human-centred perspective of the logistic system.

4.1 Tasks Replacement by Full Automation

Concerning the technology, which replaces completely some tasks that were previously performed by logistics operators, such as it occurs with automated transportation, packaging or storage solutions, it is possible to identify the following major challenges:

- *Interoperability* – in order to guarantee an effective communication and data/information exchange among different devices and systems, proper technological efforts are required, including the adoption of interoperability and cybersecurity standards for networking and data-sharing. Since this challenge regards the Industry 4.0 paradigm at large, it is one of the most addressed and researched topics.

- *Human Role in Controlling Automated Systems* – this challenge concerns with human intervention in control systems (i.e. the human-in-the-loop) over fully automated logistics systems. The 'intelligence' embedded in these systems, in fact, allows adopting decentralised control strategies, providing logistics systems with a high degree of autonomy in making decisions. The role of humans, however, can still be relevant in 'supervisory control' of all these smart systems, and for this purpose, designing efficient human-computer and human-machine interfaces is essential and represents a complex activity.

- *Employee Reduction* – The push towards automation and digitalisation in "Industry 4.0" has promoted numerous universities, industries and organisations such as the WEF (World Economic Forum[*]) to make assessments about the future of the jobs market. Predictions deviate wildly, ranging from 50% reduction of jobs to suggestions of a future with a surplus of new jobs. Due to the obvious reduction of traditional work tasks performed by human operators, automation is likely to reduce the total work-

force number and the physical presence of people on the shopfloor and warehouses. In logistics areas, this may cause anxiety among employees afraid of being decimated, especially in low-wage jobs. To address this challenge, educational institutions, companies and policy-makers are working hard towards re-skilling and up-skilling the workforce to avoid potential job losses. Thus enabling workers to acquire new skills and competencies related to "digital technologies", which may be spent in this evolving labour market.

- *Economic Perspective* – introducing new technologies in logistics may require huge investments, mainly in those areas that concern with the implementation of relevant automation solutions. However, justifying such investments demand a clear understanding of the expected benefits, which should be properly quantified. Moreover, estimating the Return On Investment of the *Logistics 4.0* solutions is challenging for companies since it requires the performance evaluation of the current systems and a clear idea about the future state of the system in terms of processes and involved resources. Furthermore, it can occur that *Logistics 4.0* solutions enable new business opportunities, for instance, the availability of new data from the field can allow the logistics systems providers to offer novel (digital) services, therefore, create new revenue streams.

4.2 Tasks Assistance and Augmentation Systems

Concerning the technology that will support logistics operators' tasks, it is possible to identify the following major challenges:

- *Human-Computer & Human-Machine Interfaces Design* – the frequent interactions among logistics operators and new technological devices and systems pose some challenges, from a behavioural and technological point of view, concerning the need to design user-friendly human-computer and human-machine interfaces. Despite this topic has been often addressed by researchers, there is still room for improvements in the human-centred design of devices, systems and tools. This is even more relevant for all the wearable systems since as already acknowledged in some real industrial cases, these systems can interfere with privacy rights and can affect the psycological traits of the logistics operators.

- *Organisational Changes* – as hinted previously in the case of automated intelligent logistics systems, also in the case of human decisions, the availability of integrated data and information at various levels will promote the adoption of decentralised organisational structures. Certainly, the *Logistics Operators 4.0* assisted and augmented by technologies will increase their awareness over the whole production and logistics processes. This is also true and more important at a higher level, concerning the digital supply chain integration.

- *New Skills & Competencies* – as a lot of logistics systems become semi- or fully-automated, logistics operators will require to acquire new skills and competencies for effectively "co-work" with their new software and hardware social robot companions and helpers as well as to train

---

[*] https://www.weforum.org/projects/future-of-work

their new AI-systems, explaining the outcome of their tasks and sustaining their proper use. The required competencies encompass technical knowledge of the digital devices and systems, as well as interpersonal and methodological skills to deal with the complex and integrated smart logistics environment.

5. CONCLUSIONS

The introduction of *Industry 4.0 technologies* in the manufacturing and logistics systems will reshape the human work, requiring an evolution towards the *Operator 4.0 paradigm.* In order to contribute on the ongoing discussion about this paradigm shift, this paper aimed at focusing on the evolution of the role of operators in the field of logistics, finally proving a definition of the *Logistics Operator 4.0.*

In particular, the *Industry 4.0 technologies* that support logistics operators have been discussed and classified according to the internal and external logistics areas in which they are applied. In addition, these technologies in logistics have been distinguished between *enabling technologies* that provide the basic 'smart functionalities' to the logistics system and *supporting technologies* that are directly interacting with operators. From the analysis of the scenarios in which the *Logistics Operator 4.0* is immersed, several challenges emerge as relevant and demand for future developments, which will be the object of further research. Along with more technical issues, the increasing interactions of operators and technologies in logistics will require relevant researches about the human-computer and human-machine interfaces, concerning both the control of fully automated systems and the ergonomic usage of new devices. In parallel with this, the organisational changes that will affect the *Logistics 4.0* need proper investigation, in order to depict future scenarios of hybrid human-machine decision-making processes.

REFERENCES

Barreto, L.; Amaral, A. and Pereira, T., (2017) "Industry 4.0 Implications in Logistics: An Overview". Procedia Manufacturing, Vol. 13, pp. 1245-1252.

Cimini, C.; Lagorio, A.; Pirola, F. and Pinto, R. (2019). "Exploring Human Factors in Logistics 4.0: Empirical Evidence from a Case Study". 9th IFAC Conference on Manufacturing Modelling, Management and Control.

Gong, Y. and De Koster, R. (2008). "A Polling-Based Dynamic Order Picking System for Online Retailers". IIE Transactions, 40(11):1070-1082.

Grosse, E.H.; Calzavara, M.; Glock, C.H. and Sgarbossa, F. (2017). "Incorporating Human Factors into Decision Support Models for Production and Logistics: Current State of Research". IFAC-PapersOnLine, Vol. 501, pp. 6900-6905.

Hofmann, E. and Rüsch, M., (2017) "Industry 4.0 and the Current Status as well as Future Prospects on Logistics". Computers in Industry, Vol. 89, pp. 23-34.

Lasi, H.; Fettke, P.; Kemper, H.-G.; Feld, T. and Hoffmann, M. (2014). "Industry 4.0". Business and Information Systems Engineering, 6(4):239-242.

Müller, J.M. and Voigt, K.-I. (2018). "The Impact of Industry 4.0 on Supply Chains in Engineer-to-Order Industries –

An Exploratory Case Study". IFAC-PapersOnLine, Vol. 5111, pp.122-127.

Park, S. and Lee, S. (2016). "A Study on Worker's Positional Management and Security Reinforcement Scheme in Smart Factory using Industry 4.0-based Bluetooth Beacons". Advances in Computer Science and Ubiquitous Computing, Springer, pp. 1059-1066.

Romero, D.; Stahre, J.; Wuest, T.; Noran, O.; Bernus, P.; Fasth-Berglund, Å and Gorecky, D. (2016a). "Towards an Operator 4.0 Typology: A Human-Centric Perspective on the Fourth Industrial Revolution Technologies". 46th International Conference on Computers & Industrial Engineering, pp. 1-11.

Romero, D.; Bernus, P.; Noran, O.; Stahre, J. and Fast-Berglund, Å. (2016b). "The Operator 4.0: Human Cyber-Physical Systems & Adaptive Automation Towards Human-Automation Symbiosis Work Systems". Production Management Initiatives for a Sustainable World, Springer, IFIP, AICT 488, pp. 677-686.

Schmidtke, N.; Behrendt, F.; Thater, L. and Meixner, S. (2018). "Technical Potentials and Challenges within Internal Logistics 4.0". 4th International Conference on Logistics Operations Management, pp. 1-10.

Strandhagen, J.O.; Vallandingham, L.R.; Fragapane, G.; Strandhagen, J.W.; Stangeland, A.B.H. and Sharma, N. (2017a). "Logistics 4.0 and Emerging Sustainable Business Models". Advances in Manufacturing, 5(4):359-369.

Strandhagen, J.W.; Alfnes, E.; Strandhagen, J.O. and Vallandingham, L.R. (2017b). "The Fit of Industry 4.0 Applications in Manufacturing Logistics: A Multiple Case Study". Advances in Manufacturing, 5(4):344-358.

Szymańska, O.; Adamczak, M. and Cyplik, P. (2017). "Logistics 4.0 – A New Paradigm or Set of Known Solutions?". Research in Logistics and Production, 7(4): 299-310.

van Lopik, K.; Schnieder, M.; Sharpe, R.; Sinclair, M.; Hinde, C.; Conway, P., West, A. and Maguire, M. (2020). "Comparison of Insight and Handheld Navigation Devices toward Supporting Industry 4.0 Supply Chains: First and Last Mile Deliveries at the Human Level". Applied Ergonomics, Vol. 82, 102928, doi: 10.1016/j.apergo.2019.102928.

Wahrmann, D.; Hildebrandt, A.C.; Schuetz, C.; Wittmann, R. and Rixen, D. (2019). "An Autonomous and Flexible Robotic Framework for Logistics Applications". Journal of Intelligent & Robotic Systems, 93(3-4):419-431.

Wamba, S.F. and Akter, S. (2015). "Big Data Analytics for Supply Chain Management: A Literature Review and Research Agenda". Enterprise and Organizational Modeling and Simulation, Springer, pp. 61-72.

Winkelhaus, S. and Grosse, E.H. (2019). "Logistics 4.0: A Systematic Review Towards a New Logistics System". International Journal of Production Research, pp. 1-26, doi: 10.1080/00207543.2019.1612964.

Zou, O. and Zhong, R.Y. (2018). "Automatic Logistics in a Smart Factory using RFID-enabled AGVs". IEEE / ASME International Conference on Advanced Intelligent Mechatronics, pp. 822-826.