LogForum

> Scientific Journal of Logistics <

2019, 15 (3), 363-376

http://doi.org/10.17270/J.LOG.2019.354

http://www.logforum.net p-ISSN 1895-2038 e-ISSN 1734-459X

ORIGINAL PAPER

STRIVING FOR EXCELLENCE IN AI IMPLEMENTATION: AI MATURITY MODEL FRAMEWORK AND PRELIMINARY RESEARCH RESULTS

Anna Paula Tanajura Ellefsen[1], Joanna Oleśków-Szłapka[2], Grzegorz Pawłowski[3], Adrianna Toboła[4]

1) Telenor, Oslo, **Norway**, 2) Poznan University of Technology, Poznań, **Poland,** 3) WSB University in Poznan, Poznań, **Poland**, 4) Poznań School of Logistics, Poznań, **Poland**

ABSTRACT. **Background:** In hereby article authors try to summarize how AI can be use by companies within production and warehousing. On the basis of previously developed Logistics 4.0 maturity model authors also propose Artificial intelligence maturity levels and on its basis a survey has been conducted in selected Polish and Norwegian companies and actual AI state of development and maturity levels has been recognized. However authors present preliminary stage of research as a multi case study which will be further developed and extended in order to identify branches and areas with a hugest potential to enhance AI utilization.

Furthermore paper presents potential directions of Artificial intelligence implementation as well as tools that can be useful to deal with big data and optimization problems predicted not only for big companies but also SMEs. Authors propose term Artificial Intelligence 4.0 to point out the actual trends in the scope of Industry 4.0 and Logistics 4.0 and revolution with respect to AI. Without doubt AI is a big challenge for manufacturing companies as well as Transport and Logistics Industry and its application should be increased and extended in solving practical problems.

Methods: Methodology applied by authors of hereby paper can be divided on following stages: literature analysis, enlargement of AI maturity model, development of a questionnaire, multi-case studies in Norway and Poland.

Results: The literature search showed a cognitive gap due to fact there is a little of literature dealing with problem of Artificial intelligence maturity models as well as Logistics 4.0 and Artificial Intelligence. Artificial intelligence maturity levels can be combined with Logistics 4.0 maturity models thus relations between actual level of logistics maturity and AI readiness in companies will be recognized. Due to such analysis it will be possible to develop complex roadmap with the organization's strategic guidelines how to deal with Logistics 4.0 and AI. All the companies investigated in this preliminary study could be classified as AI Novices: Companies that have not taken proactive steps on the AI journey and are at best in assessment mode. Even the bigger companies with more automated solutions cannot visualize the benefits AI can bring.

Conclusions: Authors see potential to apply aforementioned model to investigate AI maturity levels in logistics companies and combine obtained results with previously developed Logistics 4.0 maturity model. Authors propose to introduce term Artificial Intelligence 4.0 to emphasize the importance of artificial intelligence with respect to Logistics 4.0 and Industry 4.0.

Key words: Industry 4.0, Logistics 4.0, Artificial intelligence 4.0, Artificial intelligence, maturity levels.

INTRODUCTION

Motivation

Artificial intelligence (AI) is important because it enables dealing with difficult problems, and the solutions to those problems can be applied to sectors important to human wellbeing—ranging from health, education and commerce to transport, utilities and entertainment. Today, as software is present in every aspect of human life and business activity, primary source of value creation is the

Citation: Ellefsen A.P.T., Oleśków-Szłapka J., Pawłowski G., Toboła A., 2019. Striving for excellence in AI implementation: AI Maturity Model framework and preliminary research results. LogForum 15 (3), 363-376, http://doi.org/10.17270/J.LOG.2019.354

Received: 10.05.2019, Accepted: 10.06.2019, on-line: 01.07.2019.

processing of information. To make the process more intelligent, machine learning will yield benefits both humble and historic. Artificial intelligence (AI) is becoming one of the promising tools implemented in the scope of Industry 4.0 and Logistics 4.0. However, so far few companies use AI in practice. Main reason of this fact is high cost and difficulty of implementation. Practitioners and researchers who analyze the trends of the current industrial resolution see the need to intensify the utilization of AI in practical applications.

Due to fact that most agree that the explosive growth of AI is an inevitable. The Fourth Industrial Age will burn through massive amounts of data, with potentially hundreds of thousands of analysts employing AI tools to make sense of it all. It has also been stated by Sundar Pichai, CEO of Google that in the next 10 years, we will shift to a world that is AI-first.

In today's business, Industry 4.0 is driven by digital transformation in vertical/horizontal value chains and product/service offerings of the companies. The required key technologies for Industry 4.0 transformation such as artificial intelligence, internet of things, machine learning, cloud systems, cyber security, adaptive robotics cause radical changes in the business processes of organizations [Sarvari et al. 2018, Hofmann and Rüsch 2017, Schmidtke et al. 2018].

Industry 4.0 and Logistics 4.0 are defined in plenty papers editing since 2010. Logistics 4.0 definitions are nebulous and the concept is not homogenous, thus it is already at initial stage of development. Publications on the subject aim to present Logistics 4.0 as a trend important in logistics as well as solutions and technologies indispensable for its evolution [Barreto et al. 2017].

There are also analyzed challenges of contemporary market that logistics has to deal with, such as information exchange, automation, real-time big data analysis and link Logistics 4.0 to contemporary management paradigms such as sustainability. Logistics 4.0 status in terms of operational perspective is presented in the reports by research centers and logistic services providers [Fraunhoffer IFF 2016, DHL 2015, Dussmann Group 2016].

Hence, the list of methods and tools constituting Logistics 4.0 includes sources of data such as smart low battery consuming sensors, GPS, RFID tags, as well as the Internet of Things, drones, and innovative applications, making logistic processes smarter, more connected, automated and robotized, which undoubtedly improves logistic system performance and contributes to improved performance of supply chains.

Paper presents actual review of literature referred to Logistics 4.0, Artificial Intelligence with respect to Logistics 4.0 as well as maturity models and readiness levels (terms will be defined in section 3.1). Based on aforementioned backgrounds the novelty of proposed model is confirmed.

In the literature authors have found numerous examples of maturity models for business processes, as well as Industry 4.0 [Bowersox et al. 2000, Bubner et al. 2014, Caloghirou et al. 2004, Czaja 2016], nevertheless, there is a gap in the field of Artificial Intelligence and Logistics 4.0. Logistics 4.0 maturity models have been developed by [Oleśków-Szłapka, Stachowiak 2018, Gajsek et al. 2018]. Authors' Logistics 4.0 Model was used to define criteria with which companies are classified into five types. This classification is based on the following three aspects of logistics: (1) management, (2) flow of material, (3) flow of information, which becomes naturally three dimensions for Logistics 4.0 solutions. According to authors, the term 'Logistics 4.0 maturity' reflects the level to which a company or a supply chain has implemented Logistics 4.0 concepts. Authors distinguish five maturity levels: Ignoring, Defining, Adopting, Managing and Integrated. The assessment of maturity level has been based on analysis of Logistics 4.0 dimensions. Authors decided that the most important determinant of maturity is management, and if integration level is coherent with at least one form of the flow (either material or information) the maturity level the two represent is assigned to the company, assuming that the latter dimension is soon to be upgraded Methodology.

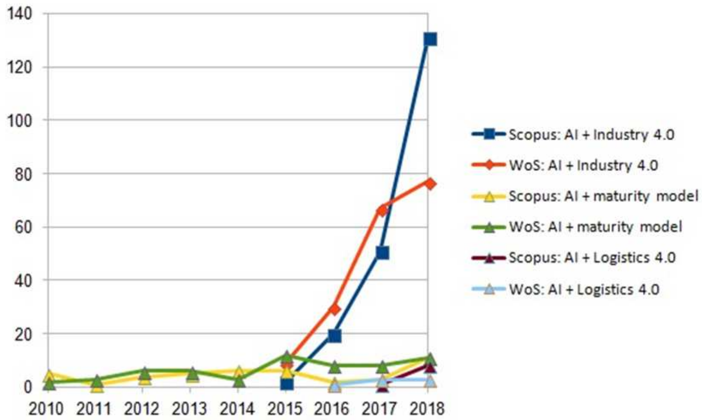
Methodology applied by authors of hereby paper can be divided on following stages: literature analysis, enlargement of AI maturity model, development of a questionnaire, multi-case studies in Norway and Poland.

The first preliminary action was the search for the literature on Logistics 4.0, artificial intelligence and maturity models. The search showed a cognitive gap due to fact there is a little of literature dealing with problem of Artificial intelligence maturity models as well as Logistics 4.0 and Artificial Intelligence. The numbers of papers found in Scopus and WoS databases is presented in Table 1. The quantity of papers referring to Artificial intelligence and Industry 4.0 is extending. From other side Artificial intelligence and maturity model is elaborated in a small number of papers either in Scopus or WoS databases. There are also still few articles discussing the subject matter of Artificial intelligence and Logistics 4.0 (see table 1 and Fig. 1).

Table 1. Numbers of papers about Artificial Intelligence, Industry 4.0, Logistics 4.0 and maturity models in Scopus and WoS databases in years 2010-2018

	Scopus: AI + Industry 4.0	WoS: AI + Industry 4.0	Scopus: AI + maturity model	WoS: AI + maturity model	Scopus: AI + Logistics 4.0	WoS: AI + Logistics 4.0
2010			5	2		
2011			1	3		
2012			4	6		
2013			5	6		
2014			6	3		
2015	2	9	6	12		
2016	20	30	2	8		1
2017	51	67	3	8	1	3
2018	131	77	11	11	8	3

Source: Own elaboration based on Scopus and WoS



Source: Own elaboration based on Scopus and WoS

Fig. 1. Number of papers in Scopus and WoS regarding Artificial Intelligence, Industry 4.0, Logistics 4.0 and maturity models

According to authors' opinion, it is the rationale for realisation of the research as recognizing new term in logistics management is interesting and promising field of research as well as potential of artificial intelligence in discussed domain could be expanded.

The second preliminary action was the survey elaborated in order to recognize and analyze actual situation of development solutions being part of Logistics 4.0 as well as applying Artificial intelligence in practice in logistics companies.

Multi-case studies have been done in Norwegian and Polish logistics companies. Authors have analyzed two big Norwegian companies (one big global clothing company and one medium sized logistics company) and two big Polish logistics companies (3PLs). The survey aimed to find out whether the companies know the term Logistics 4.0 and/or use solutions usually referred to as Logistics 4.0 solutions (identified basing on the preliminary literature review).

The survey was direct interview (CAWI - Computer-Assisted Web Interview) distributed among selected companies supported by a conversation with employees from the company. The survey questions were divided on particular parts: basic information, management area, physical process flow, information process flow, additional information. In total it consisted of 49 questions.

To identify the level of knowledge on Logistics 4.0, Industry 4.0 and the solutions within it including among other things Artificial intelligence the respondents were asked whether:

- they know the terms Logistics 4.0 and Industry 4.0?
- their warehouse is automated?
- their handling processes are automated (fully or partly)?
- their data flow and access to information is integrated in real time?
- they analyse, store and process data with contemporary technologies (i.e. Big Data, Cloud Computing)?
- they introduce innovations (when, what type of innovations)?
- they use robots to perform inventory optimization processes, location of goods in the warehouse processes, internal transport processes, shipping processes, picking processes?
- they use intelligent storage slots in your warehouse
- they use control of location by means of Internet of things (GSM, RFID, NFC, Bluetooth, ZigBee, 6LoWPAN, WirelessHART, ISA100, WiFi)
- their devices are able to collect and process data?
- their devices are able to make autonomous decisions (employees are not involved in decision making processes)?
- they use automatic monitoring in terms of intelligent environment in your company i.e. sensor networks that can make accurate measurements of environmental parameters (temperature, humidity, light etc.) in buildings

Research questions formulated by authors are as follows: (1) Are logistics companies ready to go digital? (2) Are logistics companies ready to become smart and intelligent?. Authors plan to answer these questions by applying maturity assessment method to measure the digital readiness of logistics companies. The model will include causal loop with determinants and consequences of Logistics 4.0 solutions implementation, hence it will be reflecting system dynamics as it strives for logistic excellence.

AI IN INDUSTRY 4.0 AND LOGISTICS 4.0 – CHALLENGES, ACTUAL STATE AND TRENDS

The assumption of the Industry 4.0 revolution is the participation of artificial intelligence at all stages of the product's life, from its design and manufacture, through transport and storage, distribution and sale, its repeated use up to the utilization or recycling [Kusek 2018, Hofmann and Rüsch 2017].

Nowadays, most of the production processes are partly or entirely based on automation and robotics devices equipped with selected mechanisms of AI. Dedicated manufacturing processes based on CAM (Computer-Aided Manufacturing) aimed at the implementation of specialized orders (Smart Factory), are supported by control devices that have the ability to recognize the very complex and individual features of items. Such quality control will be based on machine learning algorithms, gaining experience and looking for potential defects in the entire product class [Inside 2018, Lee at al. 2018, Witkowski 2017].

Another domain in the production where artificial intelligence algorithms are already applied is solving complex optimization problems concerning planning and management [McKinsey&Company 2017]. The data from the integrated enterprise resources management system will be soon supplemented with a wide spectrum of additional data from the Industrial Internet of Things (IIoT) sensors giving detailed information about the overall production process and each element of the process separately.

Huge information resources collected in databases will be used to build complex statistical models, their analysis supported by the AI heuristic approach, resulting in optimal strategies in decision-making processes. It will also enable quick change of production as well as better allocation of resources and workforce [Inside 2018].

The use of AI in logistics will consist in an extended use of data on each element in the supply chain [McKinsey&Company 2017]. For this purpose, it is necessary to identify and locate the product in real time. The current RFID system will be supported by IIoT elements using the 5G network with high operational requirements (an order of magnitude in micrometers) [Kizza 2017, Schneider 2013, Nagy et al. 2018].

An example of the use of such techniques in transport may be intelligent containers that scan their contents and provide such data real time to external databases [Kizza 2017, Lee at al. 2018]. It will enable not only automatic preparation of reloading of goods at subsequent stages of the supply chain, including automatic sorting but elimination of gaps identified during transport (negative verification of the parameters of goods) [European Commission - Information Society and Media DG 2009].

At the level of transport management, AI will support decisions regarding the valuation and profitability of orders, and plan their implementation through the optimization of freights. It will also support dispatchers' decisions regarding the selection of the contractor [Inside 2018].

At the stage of storage, the AI system support will be the automatic identification of goods through the new generation of intelligent storage slots, monitoring its content on an ongoing basis, both for solid and liquid materials (quantitative, weight, volume, chemical analysis). Through automatic detection, the storage conditions of the product in the selected warehouse segment will also be adjusted, which will contribute to energy savings. Thanks to AI it will also be possible to optimize the distribution of goods on a current basis using variable storage methods based e.g. on genetic algorithms [Kudelska and Pawłowski 2019].

Continuous recording of parameters, both at the stage of production as well as transport and storage in complex databases will create a full history covering every moment of product life. This will allow automatic reading of the current (or past) status, full verification in real time, e.g. due to the requirements regarding the suitability of the product for use [European Commission - Information Society and Media DG 2009]. It will also be possible to forecast the product's behavior in any perspective.

The distributor of the product will have a smart marketing environment (AI Marketing Cloud), insight into current sales trends through commodity exchanges, automatic "follow-up" for business contacts and sales support tips [Inside 2018]. Linking this information with the current demand of retail recipients (among other things by monitoring the goods on store shelves or orders via online stores) will allow adjusting the entire supply chain to the current market needs [Kusek 2018] .

The intention of the Industry 4.0 concept is also to record the history of the use of the product at the recipient, the ability to automatically set up maintenance intervals, inspections or to determine the end of acceptable use of the product. However, these are issues subject to additional legal regulations that are hard to be predicted now.

We know, however, that the waste product will be subject to recycling or recycling already planned at the design stage but taking into account its specific history recorded in the database [European Commission - Information Society and Media DG 2009].

In order for a given vision of Industry 4.0 to be implemented, appropriate conditions must be created in the ICT infrastructure that provides high-speed, super-fast and delay-free connections enabling real-time monitoring. The information will be collected through fully identifiable (IPv6) IIoT nodes, enabling fully autonomous contacts at all possible levels of IIoT network architecture (D2D, D2S, S2S), [Kizza 2017, Schneider 2013, IoT Standards & Protocols Guide 2018, Ashraf and Habaebi 2015, Hofmann and Rüsch 2017].

The presence of fiber-optic networks guarantees fast access to database centers anywhere and from anywhere in the world. Now the challenge is to build mobile networks. The 5GPPP is a joint initiative between the European Commission and European ICT industry (ICT manufacturers, telecommunications operators, service providers, SMEs and researcher Institutions) and they are dedicated to deliver solutions, architectures, technologies and standards for the ubiquitous next generation communication infrastructures of the coming decade [5G PPP 2019]. Many initiatives from 5GPPP and other related groups present industrial applications for 5G. The plans of most EU countries are the expansion of the 5G network (the Metis 2020 project) [European Commission - Information Society and Media DG 2009, European Commission 2015].

According to 5GACIA, the Alliance for Connected Industries and Automation, the wireless communication, and in particular 5G, is an important means of achieving the required flexibility of production, supporting new advanced mobile applications for workers, and allowing mobile robots and autonomous vehicles to collaborate on the shop floor. [5GACIA 2018] . In this context, 5G is expected to be the industrial internet that will support the full potential of Industry 4.0. It is also extremely important for Logistic 4.0 especially regarding the communication solutions that goes beyond the limits of the factory.

The networks will guarantee the transmission of information at the level of 10Gb/s (uplink) and 20Gb/s (downlink), creating the so-called "Internet superfluity" enabling the placement of any services anywhere. Of particular interest is the mMTC standard (massive Machine Type Communication) defining the network traffic conditions in the IoT area [European Commission 2015].

One of the biggest problems will be to ensure the full security of such communication. Reports that appeared in recent years warn against the possibility of attacks on unsecured IoT networks and taking control over them, which may have unpredictable consequences. Therefore, it will be necessary to define very strict rules and regulations both in relation to the IoT itself [European Commission 2015] and more broadly in relation to the entire AI [IEC 2012].

AI MATURITY MODEL

Organizational maturity

Maturity can be defined as “the state of being complete, perfect or ready” [Fraser et al. 2002, Mettler 2009, Karkkainen et al. 2014, Maier et al. 2012]. Maturity is referred to the state of growth, level of excellence, as in [Maier et al. 2012], where the process of bringing something to maturity means bringing it to a state of full growth, and to improvement and excellence. Crosby was among the first to propose, in 1979, a quality management model with fives levels of maturity [Kwak and Ibbs 2002, Mazur and Stachowiak 2014].

Technological readiness can be defined as how ready or mature a technology that can be applied. Definition of "readiness" is indicating a possible difference between "ready" and "not ready" of a technology or a difference "technology readiness levels" to be used or applied according to its usefulness [Febriani and Djatna 2016].

The term readiness is associated with maturity and in this paper its interpretation is as in [32], meaning that the difference between readiness and maturity is that readiness assessment takes place before engaging in the maturing process whereas maturity assessment aims for capturing the as-it-is state whilst the maturing process.

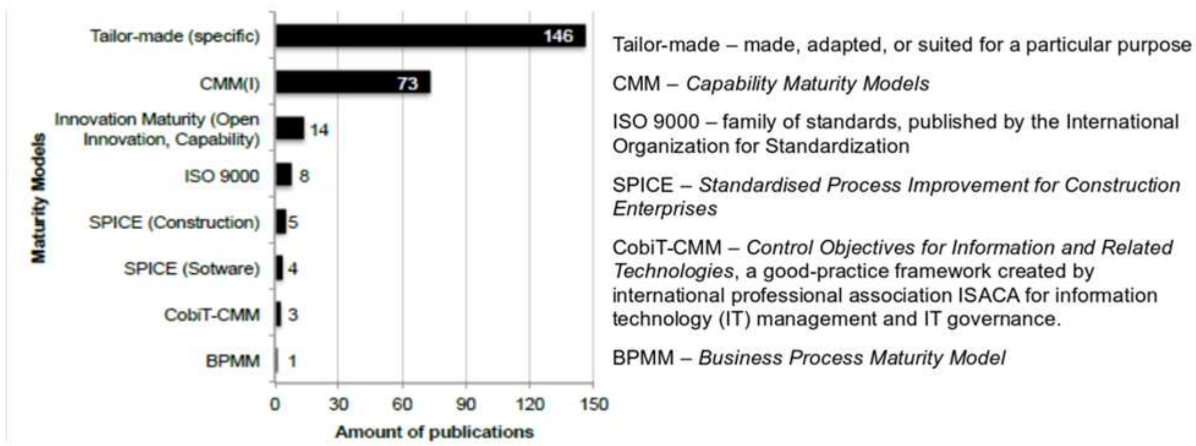
There are numerous maturity and readiness models published, including the ones by [Schumacher et al. 2016], referred to Industry 4.0 readiness, but also technology Readiness Level (TRL) by US DOD and developed by NASA [Heder 2017] and Manufacturing Readiness Level (MRL) also by DOD [Wheeler and Ulsh 2010].

Technology readiness levels (TRLs) are based on maturity scale that consists of nine levels, each one requiring the technology to be demonstrated in incrementally higher levels of fidelity in terms of its form, the level of integration with other parts of the system, and its operating environment than the previous, until at the final level the technology is described in terms of actual system performance in an operational environment [GAO 2016].

Most of maturity and readiness models are tailor made, referring to specific aspects and management areas (See Fig. 2).

Maturity models in literature have different characteristics: they can be of moderate or high complexity, maturity levels can be described in simple or complex manner. The enterprises need to follow new innovations and new technologies to preserve the competitive advantages therefore maturity models and readiness models without doubt can be useful and powerful tools to complete technology, innovation and product roadmaps.

Authors in their research use Logistics 4.0 maturity model developed by [Oleśków-Szłapka and Stachowiak 2019] as well as AI maturity model to assess actual level of maturity in these domains (Logistics 4.0 and Artificial Intelligence 4.0).



Source: Batz et al. 2018

Fig. 2. Published maturity models by area

AI maturity model – framework

Literature analysis shows that level of AI is assessed by means of AI readiness models. Majority of them have been developed by research centers and commercial entities i.e. Accenture, Capgemini, Intel, IBM, and McKinsey.

Authors found model describing Artificial Intelligence maturity which is based on five core pillars that form the critical foundations for AI-driven communication service providers

(CSP): strategy, organization, data, technology, and operations. In this model four core phased where identified: AI Novice, AI Ready, AI Proficient, AI Advanced (see table 2) [Pringle and Zoller 2018].

Table 2. AI maturity models in T.Pringle and E.Zoller model

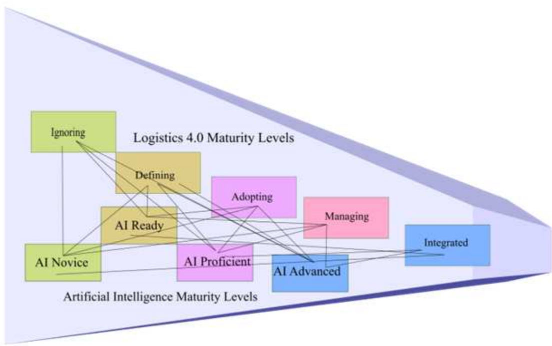
AI Novice	AI Ready	AI Proficient	AI Advanced
Has not taken a proactive steps on the AI journey and at best is in assessment mode	Sufficiently prepared in terms of strategy, organizational setup and data availability to implement AI	A reasonable degree of practical experience and understanding of how to move forward with AI but there are still gaps and limitations	A good level of AI expertise and experience with a proven track record across a range of use cases

Source: Pringle and Zoller 2018

Authors see potential to apply aforementioned model to investigate AI maturity levels in logistics companies and combine obtained results with previously developed Logistics 4.0 maturity model. Authors propose to introduce term Artificial Intelligence 4.0 to emphasize the importance of artificial intelligence with respect to Logistics 4.0 and Industry 4.0. Current trends among manufacturing and logistics companies if they are wishing to implement Logistics 4.0 solutions.

Artificial intelligence maturity levels can be combined with Logistics 4.0 maturity models (see Fig. 3.) thus relations between actual level of logistics maturity and AI readiness in companies will be recognized. Due to such analysis it will be possible to develop complex roadmap with the organization's strategic guidelines how to deal with Logistics 4.0 and AI.

Combinations of AI and Logistics 4.0 maturity levels will also enable to evaluate actual state of digitalization, automation, robotization, autonomy, intelligence and self-awareness in particular companies. Authors want to justify or fail hypothesis that Logistics companies are long away from Artificial intelligence and Logistics 4.0 solutions applied effectively in practice.



Source: own elaboration

Fig. 3. Logistics 4.0 Maturity Levels and Artificial Intelligence Maturity Levels

Authors aim to investigate what features are indispensable to take benefit from Artificial intelligence and how it AI maturity is correlated with Logistics maturity. Based on research AI readiness levels will be defined (1-5). Logistics 4.0 maturity levels has already been assessed within selected Polish companies. Due to small numbers of respondents in preliminary research authors apply grey systems to select appropriate maturity level for surveyed companies. The article discussing these issues will be published in the second quarter of 2019 and presented on 25th ICPR conference in Chicago.

Further increasing the group of respondents will allow the use of statistical quantitative analysis methods. Logistics 4.0 maturity of Polish companies providing logistic services will be compared with the correspondent data on companies representing the same industry but operating on Norwegian market. At this stage authors plan to apply statistical analysis: multidimensional comparative analysis using basics statistics and multiple correspondence analysis (MCA) to detect and represent similarity and diversity across countries.

Next phases comprise statistical analysis: (1) chi-square independence test to verify the relation between the level of maturity and factors indicated (competitive position, size, development dynamics, number of services offered, presence of foreign capital, level of internationalization of operations, number of innovations) and assumption of selected measures of association adjusted to nominal and ordinal data with testing correlation significance using the data from published reports ranking the companies providing logistic services; (2) Multi-criteria decision analysis (MCDA) to analyze the importance and the relations among the main determinants of Logistic 4.0 solutions and rank data; using the technique based on the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method to build the structural model with position and relations among the determinants showed at the Impact-Digraph-Map.

AI maturity – preliminary research in Norway and Poland

After the literature review and the elaboration of the survey as presented in Chapter 1.2, a multi-case study was conducted to validate the methodology and get more insights for a future extended quantitative study in Norway and Poland.

The research was focused on the use of technologies in warehouse facilities and consisted of questionnaires answered by middle management professionals. They were asked about how often the company introduces innovative projects and the barriers for that. It was possible to observe that bigger companies are more committed to innovative projects. They can see more benefits from such projects than professionals in smaller companies. Both small and large companies answered that the warehouse processes and process management areas receive more attention than human resource management or transport processes. All of them pointed to budget constraints as the reason for not implementing more innovation projects.

Regarding physical process flow, the picking process, shipping process, internal transport processes, localization of goods in the warehouse and inventory optimization were investigated. At the biggest company investigated in Norway, all these processes were considered partly automated, expect for inventory optimization. This is not yet automated but is intended to be so in the future. None of the respondents apply robots in the physical process flow, but there are interests in the use of robots in the future in areas such as shipping and internal transportation. The small companies do not have automation in their process and no plans for introducing this in future projects. The situation in Poland is quite similar. Bigger companies are investing in modernization of their warehouses and automating selected processes. More innovations are introducing companies with international capital.

The situation is similar in the information process flow. The companies were asked about the use of real-time identification technologies, electronic document flow, real-time data access and their data analysis process. Only bigger companies were enthusiastic about real-time data solutions and data analysis.

The respondents were asked whether their company's devices are able to make autonomous decisions, to learn during processes and to communicate to each other and with employees, but they were not able to answer that. Those questions are crucial to understand the level of AI maturity and how the company is prepared to grow towards AI. The respondents did not know about this topic or could not give concrete examples of AI applications.

All the companies investigated in this preliminary study could be classified as AI Novices: Companies that have not taken proactive steps on the AI journey and are at best in assessment mode. Even the bigger companies with more automated solutions cannot visualize the benefits AI can bring. Despite the amount of research showing the benefits of the use of smart sensors, data analysis tools, tracking systems, and machine learning, the industry is still in a novice stage regarding AI applications.

For further investigations, authors intend to increase the number of respondents, extending the study to different company locations and innovation ecosystems. It will be necessary to access more companies as well as different employees in the same company. It will be important to see the different perspectives of the employees regarding innovation and AI solutions.

CONCLUSION AND FUTURE RESEARCH

Both companies and drivers will benefit from the technology. Autonomous technology will make their jobs easier and safer, which may keep many on the job longer. Authors predict that companies' maturity levels in terms of Logistics 4.0 and AI should be improved. Managers are responsible for introducing innovations, undertaking appropriate decisions to facilitate human jobs, to make job easier and safer. On the one hand, artificial intelligence could form the basis for huge productivity gains and improved quality of life. On the other hand it could lead to a radical change in the world of work. That is to say nothing of the ethical and societal issues that we must consider if machines acquire greater and greater intellectual capacity.

Multi-case studies revealed that companies are not familiar with Logistics 4.0 solutions as well as they do not take advantage from AI potential. Despite of barriers related with budget, technology, resources an undeniable challenge it to prepare for the technological challenges of future employees.

Authors' actual research is focused on surveying bigger target group from Norway and Poland. Companies surveyed are logistics companies as well as production companies. Identification of AI 4.0 and Logistics 4.0 maturity of companies will enable assessment of the industry condition in Poland and Norway and will provide data for analysing correlations between the Logistics 4.0 and AI 4.0 maturity levels in the company as well as between its competitive position, size, development dynamics, number of services offered, structure of capital and level of internationalization of operations.

Finally authors want to develop the causal loop with feedbacks between the determinants and consequences of Logistics 4.0 solutions implementation and AI maturity levels and combine Logistics 4.0 Maturity Model and AI Maturity model with dynamic model of behavior of a company providing logistic services based on feedbacks between the levels of maturity and competitive position, size, development dynamics, number of services offered, structure of capital, level of internationalization of operations and number of innovations. There is also potential to search correlations with additional parameters collected through surveys.

Organizations should first understand their own readiness for taking advantage of Artificial intelligence which is the ability and intend to develop, establish and implement a set of processes for the efficient use of Artificial intelligence. Maturity levels and readiness levels help decision makers understand where to prioritize efforts. Many companies are still unfamiliar with deploying AI applications as well as other Logistics 4.0 tools. Progress to the next stage of maturity is dependent on having the right elements in terms of skills, resources, technology processes and management methods.

ACKNOWLEDGMENTS AND FUNDING SOURCE DECLARATION

Statutory fund of Poznan University of Technology.

REFERENCES

Ashraf Q.M., Habaebi M.H., 2015. Introducing Autonomy in Internet of Things, Recent Advances in Computer Science, Proceedings of the 14th International Conference on Applied Computer and Applied Computational Science (ACACOS '15), WSEAS, 215-221, ISBN: 978-1-61804-297-2

Barreto L., Amaral A., Pereira T., 2017. Industry 4.0 implications in logistics: an overview, Procedia Manufacturing, Elsevier, http://doi.org/10.1016/j.promfg.2017.09.045

Batz A., Kunath M., Winkler H., 2018. Discrepancies between Cluster Services and SMEs' Needs Constraining the Creation of a Culture of Innovation Amidst Industry 4.0, LogForum, 14 (3) 387-405, http://doi.org/10.17270/J.LOG.2018.286

Bowersox D.J., Closs D., Stank T., 2000. Ten Mega-Trends that will Revolutionize Supply Chain Logistics, Journal of Business Logistics, (21)1-16, http://doi.org/10.5325/transportationj.54.1.0007

Bubner M., Helbig R., Jeske M., 2014. Logistics trend radar, Delivering insight today. Creating value tomorrow, DHL Customer Solutions & Innovation, Troisdorf, Available on Internet: https://post-und-telekommunikation.de/PuT/1Fundus/Dokumente/Studien/Deutsche_Post/2014-DHL_Logistics-TrendRadar_2014.pdf (28/05/2017)

Caloghirou Y., Kastelli I., Tsakanikas A., 2004. Internal Capabilities and External Knowledge Sources: Complements or Substitutes for Innovative Performance, Technovation, (24) 29-39, http://doi.org/10.1016/S0166-4972(02)00051-2

Czaja F., Auswirkungen von Logistk 4.0 auf Mittelstand und Handwerk, 2016. Available on the Internet: www.landtag.nrw.de/portal/WWW/GB_I/I.1/EK/16.WP/EK_VI/Anlage1_Vortrag_Auswirkungen_Logistik_4.0_auf_den_Mittelstand_2016-07-01.pdf (18/02/ 2017).

Deloitte Tohmatsu Consulting LLC, 2017. Defense Policy and the Internet of Things Disrupting Global Cyber Defenses, Available on Internet: https://www2.deloitte.com/si/en/pages/public-sector/articles/gx-defense-policy-and-the-internet-of-things.html (20/05/2018)

DHL, 2015. Internet of Things in Logistics, Available on the Internet: www.dhl.com/content/dam/Local_Images/g0/New_aboutus/innovation/DHLTrendReport_Intemet_of_things.pdf (18/02/2017).

Dussmann Group, 2016. Logistics 4.0, Available on the Internet: https://news.Dussmanngroup.com/en/multimedia/news/logistics-40/ (18/02/2017).

European Commission - Information Society and Media DG, 2009. Internet of Things, Strategic Research Roadmap.

European Commission, 2015. Internet of Things, IoT Governance, Privacy and Security Issues, European research cluster on the Internet of things, Available on Internet: http://www.internet-of-things-research.eu/pdf/IoT_Cluster_Strategic_Research_Agenda_2011.pdf (16/10/2018)

Febriani E., Djatna T., 2016. The development of technology readiness assessment for commercialization innovation and product development based on digital business ecosystem, Proceedings of 9th Int.Seminar on Industrial Engineering and Management, 2-7, http://doi.org/10.1023/A:1011139021356

Fraser P., Moultrie J., Gregory M., 2002. The use of maturity models/grids as a tool in assessing product development capability, in: IEEE Int. Eng. Manag. Conf., http://doi.org/10.1109/IEMC.2002.1038431

Fraunhoffer IFF, 2016. Plan digitalization precisely with the Industry 4.0 CheckUp, , (3), Available on the Internet: https://www.iff.fraunhofer.de (10/04/2018)

5G PPP, 2019- The 5G Infrastructure Public Private Partnership, Available on Internet: https://5g-ppp.eu/ (01/03/2019).

5GACIA, 2018. 5G for connected Industries and Automation, White Paper, Second Edition, Available on Internet: https://www.5g-acia.org/fileadmin/5G (01/03/2019).

Gajsek B., Sternad M., Lerher T., 2018. Maturity Levels For Logistics 4.0 Based On Nrw'S Industry 4.0 Maturity Model, Proceedings of the 18th International Scientific conference Business Logistics in Modern Management, 695-708.

GAO, 2016. US Government Accountability Office, Technology readiness assessment guide. Best practices for evaluating the readiness of technology for use in acquisition programs and projects, August, Available on Internet: https://www.gao.gov/assets/680/679006.pdf (01/03/2019)

Heder M., 2017. From NASA to EU: the evolution of the TRL scale in Public Sector Innovation, The Innovation Journal, (22)1–23, Available on internet: https://core.ac.uk/download/pdf/94310086.pdf (02/02/2019)

Hofmann E., Rüsch M., 2017. Industry 4.0 and the current status as well as future prospects on logistics, Computers in Industry, (89)23-34, http://doi.org/10.1016/j.compind.2017.04.002

IEC 62243, 2012. Artificial Intelligence Exchange and Service Tie to All Test Environments, Available on Internet: https://webstore.iec.ch/publication/20368, 06-21

IoT Standards & Protocols Guide 2018. Comparisons on Network, Wireless Comms, Security, Industrial, https://www.postscapes.com/internet-of-things-protocols/ accessed on 15.01.2019.

Karkkainen H., Myllarniemi J., Okkonen J., Silventoinen A., 2014. Assesing maturity requirements for implementing and using product lifecycle management, Int.J.Electr.Bus., 11(2),176-198.

Kizza J.M., 2017. Guide to Computer Network Security, Computer Communications and Networks, Springer International Publishing AG 2017 http://doi.org/10.1007/978-3-319-55606-2_24.

Kudelska I., Pawłowski G., 2019. Influence of assortment allocation management in the warehouse on the human workload, Central European Journal of Operations Research, http://doi.org/10.1007/s10100-019-00623-2.

Kusek M., 2018. The Internet of Things, Today and Tomorrow, 2018 41st International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), http://doi.org/10.23919/MIPRO.2018.8400064

Kwak Y.H., Ibbs W.C., 2002. Project Management Process Maturity Model, Journal of Management In Engineering. 18, 3, 150-155, http://doi.org/10.1061/(ASCE)0742-597X(2002)18:3(150)

Lee C. K. M., Yaqiong K. K. H., Choy K. L., 2018. Design and application of Internet of things-based warehouse management system for smart logistics, International Journal of Production Research, 56(8) 2753-2768, http://doi.org/10.1080/00207543.2017.1394592

Maier A.M., Moultrie J., Clarkson P.J., 2012. Assesing organizational capabilities: Reviewing and guiding the development of maturity grids, IEEE Trans.Eng.Manag., (59)138-159, http://doi.org/10.1109/TEM.2010.2077289

Mazur A., Stachowiak A., 2014. The framework of methodology for identification of organizational maturity with assessment of excellence level of logistics systems, in: Abrudan I., The Management between profit and social responsibility, Procedeengs of the 4th Review of Management and Economic Engineering International Management Conference, 18-20 September 2014, Todesco Publishing House, Cluj-Napoca, Romania, 415-423, ISSN 2247 – 8639.

McKinsey&Company, 2017. Artificial Intelligence. The next digital frontier?, Available on Internet:

https://www.mckinsey.com/~/media/McKinsey/Industries/Advanced%20Electronics/Our%20Insights/How%20artificial%20intelligence%20can%20deliver%20real%20value%20to%20companies/MGI-Artificial-Intelligence-Discussion-paper.ashx (12/10/2018)

Mettler T., 2009. A design science research perspective on maturity models in information systems, (2009), Available on Internet, https://www.alexandria.unisg.ch/publications/214531 (03/03/2018)

Nagy J., Olah J., Erdei E., Mate D., Popp J., 2018. The Role and Impact of Industry 4.0 and the Internet of Things on the Business Strategy of the Value Chain-The Case of Hungary, Sustainability, vol.10, http://doi.org/10.3390/su10103491

Oleśków-Szłapka J., Stachowiak A., 2018. The Framework of Logistics 4.0 Maturity Model, in: Intelligent Systems in Production Engineering and Maintenance/ ed. Anna Burduk: Springer International Publishing, 771-781, http://doi.org/10.1007/978-3-319-97490-3_73

Polityka Inside, 2018. Iloraz sztucznej inteligencji, Potencjał AI w polskiej gospodarce, (eng. Potential of AI in Poland. Quotient of Artificial intelligence), Warszawa, Available on the Internet: www.politykainsight.pl/nowa/badania, (2/02/2019).

Pringle T., Zoller E., 2018. How to achieve AI maturity and why it matters, Ovum, June(2018), Available on Internet: https://www.amdocs.com (22/02/2019).

Sarvari P.A., Ustundag A., Cevikcan E., Kaya I., Cebi S., 2018. Technology roadmap for Industry 4.0, in: Ustundag A., Cevikcan E., Industry 4.0. Managing the digital transformation, Springer, 95-103, http://doi.org/10.1007/978-3-319-57870-5_5

Schmidtke N.,Behrendt F., Thater L., Meixner S., 2018. Technical Potentials and Challenges within Internal Logistics 4.0, 2018 4th Ieee International Conference On Logistics Operations Management (Gol)

Schneider S., 2013. Understanding The Protocols Behind The Internet Of Things, ElectronicDesign, Available on the Internet: https://www.electronicdesign.com/iot/understanding-protocols-behind-internet-things, (15/01/ 2019)

Schumacher A., Erol S., Sihn W., 2016. A Maturity Model for Assessing Industry 4.0 Readiness and Maturity of Manufacturing Enterprises, Procedia CIRP, (52)161-166., http://doi.org/10.1016/j.procir.2016.07.040

Wheeler D., Ulsh M., 2010. Manufacturing Readiness Assessment for Fuel Cell Stacks and Systems for the Back-up Power and Material Handling Equipment Emerging Markets - Technical Report NREL/TP-560-45406, Available on Internet: https://www.nrel.gov/docs/fy10osti/45406.pdf (05/06/2018)

Witkowski K., 2017. Internet of things, big data, industry 4.0–innovative solutions in logistics and supply chains management, Procedia Engineering, vol.182, 763-769, http://doi.org/10.1016/j.proeng.2017.03.197

DĄŻENIE DO PERFEKCJI WE WDRAŻANIU SZTUCZNEJ INTELIGENCJI: RAMY MODELU DOJRZAŁOŚCI SZTUCZNEJ INTELIGENCJI ORAZ WYNIKI BADAŃ WSTĘPNYCH

STRESZCZENIE. Wstęp: W niniejszym artykule autorzy starają się podsumować, w jaki sposób sztuczna inteligencja może być wykorzystywana przez firmy w produkcji i magazynowaniu. Na podstawie wcześniej opracowanych modeli dojrzałości logistyki 4.0 autorzy proponują również poziomy dojrzałości sztucznej inteligencji (AI) i na jej podstawie przeprowadzono badanie w wybranych polskich i norweskich firmach oraz rozpoznano rzeczywisty stan rozwoju i poziom dojrzałości AI. Autorzy przedstawiają jednak wstępny etap badań jako studium przypadku, które będzie dalej rozwijane i rozszerzane w celu zidentyfikowania gałęzi i obszarów o największym potencjale do zwiększenia wykorzystania sztucznej inteligencji. Ponadto w artykule przedstawiono potencjalne kierunki

wdrażania sztucznej inteligencji, a także narzędzia, które mogą być przydatne w rozwiązywaniu problemów związanych z dużymi danymi i optymalizacją przewidywanych nie tylko dla dużych firm, ale także małych i średnich przedsiębiorstw. Autorzy proponują termin Artificial Intelligence 4.0 (Sztuczna Inteligencja 4.0), aby wskazać rzeczywiste trendy w zakresie Przemysłu 4.0 i Logistyki 4.0 oraz rewolucji w odniesieniu do sztucznej inteligencji. Bez wątpienia sztuczna inteligencja jest dużym wyzwaniem dla firm produkcyjnych, jak również branży transportowej i logistycznej, a jej zastosowanie powinno zostać zwiększone i rozszerzone w rozwiązywaniu praktycznych problemów.
Metody: Metodologia zastosowana przez autorów niniejszego opracowania może być podzielona na następujące etapy: analiza literatury, rozszerzenie modelu dojrzałości sztucznej inteligencji, opracowanie kwestionariusza, studia przypadków w Norwegii i Polsce.
Wyniki: Analiza literatury wykazała lukę poznawczą z powodu faktu, że istnieje bardzo niewiele literatury dotyczącej problemu modeli dojrzałości sztucznej inteligencji, a także logistyki 4.0 i sztucznej inteligencji. Poziomy dojrzałości sztucznej inteligencji można łączyć z modelami dojrzałości logistyki 4.0, dzięki czemu zostaną rozpoznane relacje między rzeczywistym poziomem dojrzałości logistycznej a gotowością sztucznej inteligencji w przedsiębiorstwach. Dzięki takiej analizie możliwe będzie opracowanie złożonej mapy drogowej ze strategicznymi wytycznymi organizacji, jak radzić sobie z logistyką 4.0 i sztuczną inteligencją. Wszystkie firmy badane w tym wstępnym badaniu można zaklasyfikować jako nowicjuszy sztucznej inteligencji: firmy, które nie podjęły aktywnych kroków w podróży sztucznej inteligencji i są w najlepszym razie w trybie oceny. Nawet większe firmy z bardziej zautomatyzowanymi rozwiązaniami nie potrafią wyobrazić sobie korzyści, jakie może przynieść sztuczna inteligencja.
Wnioski: Autorzy widzą możliwość zastosowania wspomnianego modelu do badania poziomów dojrzałości sztucznej inteligencji w firmach logistycznych i łączenia uzyskanych wyników z wcześniej opracowanym modelem dojrzałości Logistyki 4.0. Autorzy proponują wprowadzenie terminu Sztuczna Inteligencja 4.0, aby podkreślić znaczenie sztucznej inteligencji w odniesieniu do Logistyki 4.0 i Przemysłu 4.0.

Słowa kluczowe: Industry 4.0, Logistics 4.0, sztuczna inteligencja 4.0, sztuczna inteligencja, poziomy dojrzałości

Anna Paula Tanajura Ellefsen
Telenor, Snarøyveien 30 ,Oslo, **Norway**
email: Ana-Paula.Ellefsen@telenor.com

Joanna Oleśków-Szłapka ORCID ID: https://orcid.org/0000-0001-9737-6888
Faculty of Engineering Management,
Poznan University of Technology,
Strzelecka 11, 60-965 Poznań, **Poland**
email: joanna.oleskow-szlapka@put.poznan.pl

Grzegorz Pawłowski ORCID ID: https://orcid.org/0000-0001-5019-1317
Faculty of Finance and Banking,
WSB University in Poznan,
Powstańców Wielkopolskich 5,
61-895 Poznań, **Poland**
email: grzegorz.pawlowski@wsb.poznan.pl

Adrianna Toboła
Poznań School of Logistics,
Estkowskiego 6,
61-755 Poznań, **Poland**
email: adrianna.tobola@wsl.com.pl