RESEARCH IN LOGISTICS & PRODUCTION

# LOGISTICS 4.0 – A NEW PARADIGM OR SET OF KNOWN SOLUTIONS?

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**Abstract:** Most of the publications referred to Logistics 4.0 focus on the description of the newest technologies in contemporary supply chains applications. There are also many articles which treat Logistics 4.0 as a new paradigm. Regarding the fact that there is little amount of publications in the Polish language related to Logistics 4.0, the authors are going to fill identified research gap. Systematic literature review methods were used. The purpose of the research was to define Logistics 4.0 and answer whether it is a new paradigm or a set of known technical, technological and organizing solutions. he analysis covered domestic and foreign publications selected according to an empirical criterion. The literature review proved that Logistics 4.0 is not characterized by features of a new paradigm in management sciences. Logistics 4.0 is a connection of known technical, technological and organizational solutions. The only novelty is a mere connection of above solutions in a consistent logistics concept.

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## 1. INTRODUCTION

Modern technologies are being currently developed and implemented not only in industry but also in everyday life. This is a big challenge for enterprises. One searches for such activity organisation methods that will make it possible to use potential chances and possibilities related to meeting customers' needs or maintaining a competitive advantage. The Logistics 4.0 concept is a solution that will make it feasible to meet the above challenges in the area of logistics. The question is whether Logistics 4.0 might be defined as a paradigm understood as a scientific achievement and a new theory basis (Kuhn, 2001) or a set of technical, technological and organisational solutions that are developed and adapted to the developing business needs. The aim of the article is to provide a scientific discussion about Logistics 4.0 as a new step in logistics development. Authors want to sort out terminology connected with Logistics 4.0. In scientific papers Logistics 4.0 is called: a new method, a new set of tool, a new paradigm. Authors of this paper want to demonstrate that Logistics 4.0 is not a new paradigm in management science.

Logistics as a branch faces numerous complicated challenges, i.e. related to the need for fast action and making quick decisions, performing high efficiency and elasticity that enable adoption to a customer's needs. The above challenge fulfillment depends on managing modern technologies. They are most frequently based on complicated data sources which are a cause and effect of the modern trend development at the same time (Magruk, 2016). There is a growing interest in modern technological trends among enterprises. This might be implied by the enterprises' tendency to enhance their performance and obtain a competitive advantage (Angeleanu, 2015), which both with high action quality lead to differentiating enterprises (Mentzer, Flint & Hult, 2001).

It is required by the market to keep logistics adapted to present trends and requirements of modern IT-communication and production technologies (Timm & Lorig, 2015). In logistics there are significant trends that determine its new development stages (Tadejko, 2015). The trends include, i.e.: Big Data, Internet of Things, Industry 4.0 (Ehrhardt & Partner, 2016) Cloud Logistics, Autonomous Logistics, 3D printing, Robotics & Automation, Low-cost sensor technology (Marguk, 2016). The Internet of Things, Cloud computing, Big Data and Real Time Data applications are sought mainly in manufacturing industry, commerce, software logistics and industry (Jäger, Schöllhammer, Lickefett & Bauernhansl, 2016).

# 2. THE EVOLUTION OF CONTEMPORARY LOGISTICS CONCEPTS

## 2.1. Development of logistics

Pfohl (2001) defined logistics as "activities of goods transformation planning, management and its tempo-spatial control (…), which will enable the most effective translocation from the point of dispatch to the point of reception". In turn, Bozarth & Handfield (2007) additionally pay attention to the information and service circulation. Both definitions emphasise the tempo-spatial transformation significance. In Jünemann's definition (1989) logistics is "the science of planning, controlling and steering the systems based on the flow of material, staff, energy and information" This definition lacks the spatial aspect.

**Table 1.** Evolution of Logistics

| | Period | Description |
|---|---|---|
| Era 1<br>(Farm to market) | 1916–1940 | transport and distribution of main interest,<br>base: transporting products to points of sales,<br>large influence of economics on logistics, |
| Era 2<br>(Segmented Functons) | 1940–1960 | distinguishing independent functions: warehousing, inventory management, sales and transport (coming in and out)<br>increase in the physical distribution efficiency, |
| Era 3<br>(Integrated Functions) | 1960–1970 | integration of functional areas,<br>implementation of the term „total costs" to business practice,<br>system approach,<br>distribution as a process from the reception of ready-made products from an assembly line to their delivery to the final user, |
| Era 4<br>(Customer Focus) | 1970–1985 | customer-focused,<br>customer service perceived as a physical distribution element,<br>logistics popularity increase in science,<br>interest in inventory productivity and inventory balancing costs, |
| Era 5<br>(Logistics as a Differentiator) | 1985–1997 (publication data) | logistics as a key factor in the enterprise differentiation strategy and in obtaining a competitive advantage and value added,<br>integrated supply chain management,<br>influence of IT technologies,<br>logistics perceived as a sequence of business processes, |
| Era 6<br>(Behavioral and Boundary Spanning) | Future (with respect to the article publication date) | interest in customer behaviour and integrated supply chain management,<br>logistic customer service as a priority,<br>cooperation between enterprises that perform logistic functions. |

The definitions of logistics have evolved over time because its functions and interest areas got changed. Logistics originated in military and gradually started influencing the economy (Rutner, Aviles & Cox, 2012). The non-military logistics concept came from a concept based mainly on agricultural goods transport known as physical distribution. The development of logistics depends on innovations implemented in industry, IT technologies and technological, economic, political, social or environmental factors.

Kent and Flint (1997) attempted to make an elaboration of how contemporary logistics has evolved since 1916. They divided particular development stages into 6 eras. The eras were described and ordered chronologically. The research results of Kent and Flint (1997) are presented in Table 1.

While describing the 6th era, Kent and Flint were right to forecast the ongoing trends in logistics in comparison to the ones in 1997. The researchers paid attention to a customer's role and integrated supply chain management that are currently of interest in logistics. The modern idea tendencies are reflected by such objectives as the customer's requirement individualisation, their service efficiency, elastic solutions which enable fulfillment of a purchaser's postulates. The authors identified the need for updating the table with era 7th. It includes the application of modern IT technologies with the use of Cyber-Physical Systems. They are put together to form automatic IT system networks which service and manage large amounts of real-time data. This is intended to form value added. The above solutions are typical of contemporary Industry 4.0 and Logistics 4.0 concepts (the latter one is integral part of the former one). Therefore, there is a need for quoting a few basic facts about their assumptions.

## 2.2. Industry 4.0

The term "Industry 4.0" was introduced at a trade fair in 2011 in Germany. This term is known as the 4th Industrial Revolution and is referred to new networking-based trends. Industry 4.0 predominately regards production areas related to other technological concepts, such as M2M communication, RFID technology, CPD, IoT and Cloud Computing (Wang, 2016). The term "Industry 4.0." includes the development and implementation of competitive products as well as elastic administrative, production and logistic systems (Rennung, Luminosua & Draghicia, 2016). Industry 4.0 is also perceived as CPS (Cyber-Physical Systems) integration in factories, warehousing systems and logistics (Wang, Wan, Li & Zhang, 2016) by means of the Internet of Things applications in industrial processes (Prause & Weigand, 2016).

The implementation of the above concept is exemplified by a semi-automatic assembly line which applies RFID and Bluetooth technologies and is installed in a factory of the Bosch company (Zygmunt, 2015). As part of Industry 4.0 one also uses solutions and tools that influence innovations in logistics (Istvan & Gabor)

which is considered to be a domain of the 4th Industrial Revolution (Hompel & Henke, 2014). In view of Pfohl, Yahsi and Kurnaz (2015) the largest influence of the Industry 4.0 technology and concept is expected to be on the areas of shopping, production and supply chains. There are no such fundamental changes expected in any other sector.

The consequences of the 4th Industrial Revolution for logistics is far-reaching. It is forced by the consistent implementation of such concepts as Internet of Things to rethink the fundamental logistics concepts (Hompel & Kerner, 2015).

## 2.3. Logistics 4.0

Logistics 4.0 is a narrower term than Industry 4.0 in spite of having similar assumptions. Jeschke (2016) defines the term "Logistics 4.0" from two approaches. As regards to the short-term approach Logistics 4.0 is defined as firm and mutually related processes between independent members with the use of large amounts of data. As to the medium-term approach Logistics 4.0 is defined as autonomous, self-organising systems within other systems. Similar definitions are made by Timm and Lorig (2015). In their view Logistics 4.0 is logistic systems which consist of independent subsystems. The behavior of the subsystems depends on other surrounding subsystems. This term also means process automatisation and co-organisation and the Industry 4.0 support (Hompel & Kerner, 2015).

The Logistics 4.0 definition combines two aspects: processual (supply chain processes are a subject of the Logistics 4.0 actions) and technical (tools and technologies that support internal processes in the supply chains).

Logistics 4.0 aims at enlarging the supply chain members' efficiency and performance. The supply chain is based on decentralised decision-making structures (Dussmann Group, 2016). The above objectives are to be achieved by performing 1) vertical integration of members related to hierarchical subsystems in the organisation (Czaja, 2016) and 2) horizontal integration related to the cooperation between external legal entities (Wang, Wan, Li & Zhang, 2016).

Due to the similarities between the Logistics 4.0 and Industry 4.0 concepts, the former one is based on its typical features, i.a. digitalisation, automatisation, networking and mobility (Pfohl, Burak & Kurnaz, 2015). The Logistics 4.0 technological solutions are based on using drones, self-steering vehicles, sensors, Big Data, GPS, RFID, M2M. As part of the concept, the technologies dedicated to modern enterprises use i.e. virtual reality glasses, intelligent transporters, gates, forklifts and automatic vehicles (DHL, 2015).

The Logistics 4.0 concept implementation advantages are: savings in human work, high standardisation of linking logistic functions to information pieces and the use of equipping logistic enterprises with the newest technologies (Berger). The disadvantages are: high investment costs and the IT supply network possession requirement.

It is required by the Logistics 4.0 prospect outline to state it precisely whether the 4th Industrial Revolution introduces a new paradigm. If so what kind of paradigm it is (Hompel& Kerner, 2015).

## 3. PARADIGMS IN MANAGEMENT SCIENCES

### 3.1. Classifications of management paradigms

A paradigm is a set of terms and theories which are widely accepted by scientific community members and experts on a given branch of science. A scientific paradigm is a historically changeable consensus omnium of the community of researchers from a particular discipline. This makes it possible to make progress in obtaining knowledge, solve further problems and not to return to the tackled issues (Kuhn, 2001). As to the reference literature, it is controversial to specify the number of paradigms in management sciences (Hatch, 2002). The researchers might be divided into 3 groups: one group opts for one paradigm in the management sciences, the other group claims that management is a multi-paradigmatic science, and the third group diagnoses the present state of science to be post-paradigmatic (Clegg & Hardy, 1997). In the literature there are numerous classifications of paradigms in management sciences. Hereby, the authors present the following paradigms:

- Subject division according to subdisciplines of management sciences,
- Management paradigms by M.J. Hatch,
- Cognitive frames by L.G. Bolman and T.E. Deal,
- Neopositivist-functionalist-systemic paradigm.

It is postulated by the subject division that there are separate paradigms for subdisciplines of management sciences. According to this approach each subdiscipline forms its own discourse and the discourses are not always complementary to each other. Therefore, one might distinguish such paradigms as: strategic management, human resource management, financial management, production management, quality management and many others. In turn, this does not correspond to the presented paradigm definition. It says that the consensus is shared by a large group of researchers (Sułkowski, 2015).

Hatch distinguished 4 paradigms in management sciences (Hatch 2002):

- classical – including works by Taylor, Weber and Fayol,
- modernist – it describes an organisation in functionalistic and systemic categories,
- interpretation-symbolic – it describes the organisation as a process of forming social reality,

- postmodernist–it emphasises the defragmentation of the paradigm into cultural and epistemological relativism

The division of paradigms as presented by Hatch is largely included and based on the historical development of management sciences (Sułkowski, 2015).

Bolman and Deal (2003) mentioned 4 cognitive frames focused on the following problems:

- structure – the frame is focused on the organisation as an entity intended to achieve its goals, effectively allocate resources to tasks, coordinate the tasks,
- human resource management – the frame is focused on the organisation as an entity responsible for meeting people's needs, the organsation and people need each other, people – salaries, job, development possibilities, organisation – talent, energy of its staff,
- political – the frame is focused on the organisation as a set of groups of interest (but it is assumed that the interests of particular groups might be different),
- symbolic – the frame is focused on how events are perceived by their member but not on what really happened.

This concept is not put in a bigger picture of social sciences which is its disadvantage. This classification does not exhaust all cognitive prospects in management sciences (Sułkowski, 2015).

Presently, the neopositivist-functionalist-systemic paradigm dominates in management sciences. An analytic approach and the possibility of verifying verities by means of quantitative methods are of key significance. The paradigm conforms to the neopositivist science ideal with its universal and objective character at the same time (Sułkowski, 2015). Nevertheless, there are critics of this stream who indicate the static kind of the picture implied by the description according to the paradigm. Meanwhile organisations function in the case of a lack of balance and conflicts (not always implied by rationally explainable reasons) and disintegration (Wheatley, 1999).

## 3.2. Logistics 4.0 vs. management paradigms

As part of the broader concept of Industry 4.0, Logistics 4.0 is called a new paradigm by numerous authors. In view of Kagermann, Wahlster and Helbring the prospect of the 4th Industrial Revolution is focused on implementing CSP cyber-physical systems to logistic systems. As a consequence, Industry 4.0 introduces changes to the paradigms and is called the 4th Industrial Revolution (Kagermann et al., 2013). According to Prause and Weigand Industry 4.0 is defined as a paradigm that includes a new approach to production and changes in traditional, centralised control structures in favour of decentralised structures (Prause & Weigand, 2016). In turn, it might be read from a publication by Deutsche Gesellschaft für Qualität

that numerous technologies and approaches to the revolutionary Industry 4.0 production paradigm function thanks to a synergetic CPS, Internet of Things and Big Data application (Deutsche Gesellschaft für Qualität). If Logistics 4.0 is a new paradigm, it is worth considering what paradigms it changes or replaces. In view of Hompel and Kerner Industry 4.0 trends form a kind of new puzzles in logistics. The Internet of Things – a picture of future gets more and more apparently emerged from the puzzles. Autonomous, mutually communicating CPS elements are formed by using sensors with a decentralised decision-making system (Hompel & Kerner, 2015). In the work by Suh (Suh et al. 2008) there is a table where e-manufacturing is defined as a new paradigm in the production management development (apart from lean manufacturing, agile manufacturing, holonic manufacturing).

The authors decided to verify the above statements in which Logistics 4.0 and Industry 4.0 are classified as paradigms. This was with respect to the paradigm definition and its classification applicable to management sciences (see part 3.1). In order to achieve the above goal, the article authors tabulated Logistics 4.0 and the previously mentioned paradigms applicable in management sciences.

**Table 2.** Logistics 4.0 according to management science paradigms

| Paradigm classification | Description |
|---|---|
| Subject division in accordance with subdisciplines of management sciences | Logistics 4.0 is not a new subdiscipline in the discipline of management sciences,<br>it is discussed in numerous forums whether logistics is a scientific subdiscipline or it is devoted to practical activities only,<br>thereby Logistics 4.0 cannot be a new paradigm according to this classification. |
| Management paradigms by M.J. Hatch | Logistics 4.0 belongs to the modernist prospect,<br>therefore its research subjects are objective measurements,<br>quantitative methods are used,<br>the result analysis is conducted by using statistical methods that make it possible to analyse numerous variables. |
| Cognitive frames by L.G. Bolman and T.E. Deal | Logistics 4.0 belongs to the structure frame,<br>its activity is focused on the increase in the logistic resource usage efficiency,<br>rational measurements, their analysis methods and decision structuration is intended to satisfy people's needs. |
| Neopositivist-functionalist-systemic paradigm | Logistics 4.0 belongs to this paradigm,<br>its objective is to use quantitative methods to model reality,<br>the theories, which are formed within Logistics 4.0, are a sequence of variables with cause-and-effect relations. |

Logistics 4.0 belongs to the presently existing paradigm classification in accordance with the conclusions as presented in Table 2. Thus, there is no need to create new paradigms for the sake of describing the Logistics 4.0 phenomenon.

## 4. CONCLUSION

The Logistics 4.0 concept is not exhaustively recognised from the scientific view point but is an idea developed by research institutions and enterprises. Logistics 4.0 is not science but a set of solutions. The concept does not fulfil the paradigm requirements by Kuhn as it is not a set of science formation terms and theories. As mentioned in chapter 3.2, Logistics 4.0 perfectly belongs to the present management science paradigms. The mere paradigm is a broader term and gives rises to its scientific cognition. The paradigm is a foundation of new theories which are intended to provide an explanation of a given piece of reality. In spite of a wide range of its large instruments, Logistics 4.0 is devoted to utilitarian objectives and not to describing reality. As regards to Logistics 4.0 the science makes an attempt to follow and define business-applied solutions. Furthermore, a very huge potential of implementing Logistics 4.0 assumptions and solutions to business is confirmed to exist and to be largely based on human work and decisions in this area.

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