Advanced Logistic Systems Vol. 12. No. 1. (2018) pp. 37-46, https://doi.org/10.32971/als.2019.003

LOGISTICS CONCEPTS AND LOGISTICS 4.0

ELKE GLISTAU[1]-NORGE ISAÍAS COELLO MACHADO[2]

Abstract: The paper describes the terms Industry 4.0 and Logistics 4.0 as two of the most important trends in production and logistics. Industrie 4.0 (Industry 4.0) is a German term and a synonym for the fourth industrial revolution. It is connected with the common trend of digitalization, virtualization and networking of data and information. The term Logistics 4.0 brands the specific application of Industry 4.0 in the area of logistics. Therefore a new research approach was developed the "Smart Logistics Zone" (SLZ) by Fraunhofer IFF and Otto von Guericke University Magdeburg. This is defined as a scalable examination and action area for the analysis, evaluation, planning, control, regulation and (re-) configuration of logistics solutions [1]. The Smart Logistics Zone differs into logistics objects, logistics processes, logistical systems and logistics infrastructure. Every logistics solution should be built by using all of these four aspects in a free combination by increasing dynamics and complexity. Industry 4.0 and Logistics 4.0 create new business processes. The question is, how will they change the traditional logistics concepts and strategies? The paper answers the following research questions: What are solutions of Logistics 4.0? Are there any successful realized solutions, which optimize logistics at a whole? Which requirements on logistics management will exist according to the criteria of Industry 4.0/Logistics 4.0? Are the classic logistics strategies still valid according to the digital transformation process?
Keywords: Industry 4.0, Logistics 4.0, logistics concepts, logistics strategies

1. INDUSTRY 4.0 AND LOGISTICS 4.0

The term "Industry 4.0" was first used in a high-tech-strategy project of the German government. (Compare [2] [3]) The term is based on the nomenclature of software and is used as a synonym for the fourth industrial revolution.

Basics of Industry 4.0 (Compare [4]) are the availability of relevant information in real-time by networking of all elements which are involved in the creation of value, the ability to deduce optimal value-added processes from the information and data at any time and the realization of an information-integrated value-added process.

The use of cyber-physical systems (CPS) best describes Industry 4.0. This means the integration of computation, networking and real, physical things, which provide the base for new business models and business solutions.

The term Logistics 4.0 brands the specific application of Industry 4.0 in the area of logistics. Logistics means the management of the flow of people, animals and things between an origin and the point of consumption to fulfil the requirements of the customer. Relevant technologies of Logistics 4.0 are, e.g. identification, mobile communication, localization, electronic data interchange, data analysis methods and data analytics processing. (Compare [5])

[1] Dr.-Ing. Dr. h. c. (UCLV), Otto-von-Guericke-University Magdeburg
elke.glistau@ovgu.de
D-39106, Universitätsplatz 2. Magdeburg, Germany
[2] Prof. Dr.-Ing. Dr. h.c., Central University „Marta Abreu" of Las Villas
norgec@uclv.edu.cu
Santa Clara, Cuba

2. SOLUTIONS OF LOGISTICS 4.0

Logistics can be differed into procurement (inbound) logistics, production logistics, outbound logistics and disposal logistics. Logistics 4.0 changes the principles and solutions of logistics.

Fig. 1 shows some important principles and solutions of inbound logistics by using Logistics 4.0 in connection with Lean management in a simplified way.

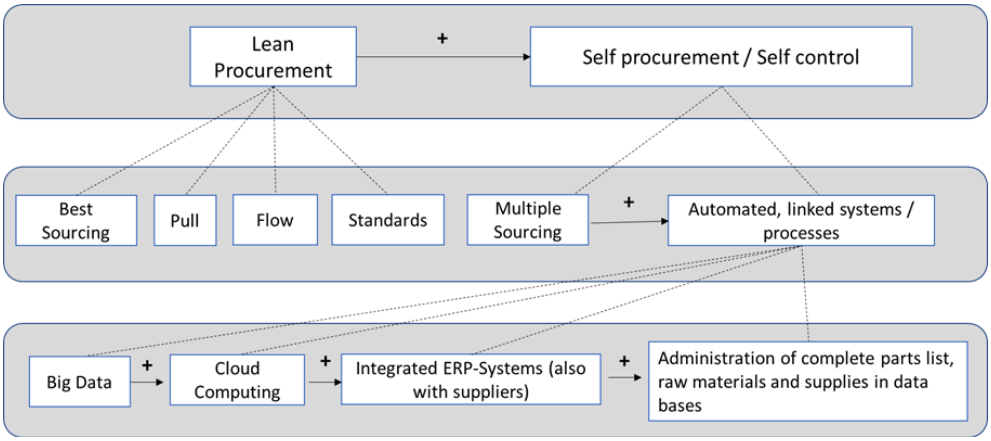

Figure 1. Inbound logistics: principles and solutions (Compare [6], p. 72)

Main target of logistics is to fulfill the customer requirements effectively and efficiently. Fig. 1 shows some targets of inbound logistics to realize an increase of speed, productivity, flexibility and transparency and to reduce costs, waste and failures. There are some principles of Lean production mentioned. These are more than the typical five, flow, standards, pull, synchronization, work cycle, integration, perfection and robustness. Holistic cyber-physical systems (CPS) are important results of Industry 4.0/Logistics 4.0. They realize the networking and automation of transportation, allocation and if necessary the use of storage systems on the basis of digitalization of processes and decentral software control. Therefore, Cloud Computing, Big Data services and decentralized Agent systems are essential. The control of the material flow is initialized by the logistical objects by themselves. They execute their workflows with own software agents.

Typical technical solutions integrate robots, sensor systems, smart products and smart handling-aids. Fig. 2 shows some more typical solutions of Logistics 4.0. (Compare [14] [15])

Smart logistical objects include the use of embedded systems to collect data, communicate and make networking. They use identification (e.g. RFID) and sensor technologies. They create transparency about the identified logistical products / load carriers and their behavior. This information builds the basis for holistic tracking and tracing solutions and for process control. So it changes the processes, where the logistic objects are involved.

Possibilities of autonomous driving have different technical solutions but realize the same task to move, to handle and to transport without a driver/a pilot. There is a great potential to improve the energy efficiency and to increase the capacity of the transport mode and space. Smart vans, trucks and busses have sensors for direction, speed and safety dis-

tances. Driving mirrors are replaced by cameras. GPS and WLAN give information about topological characteristics.

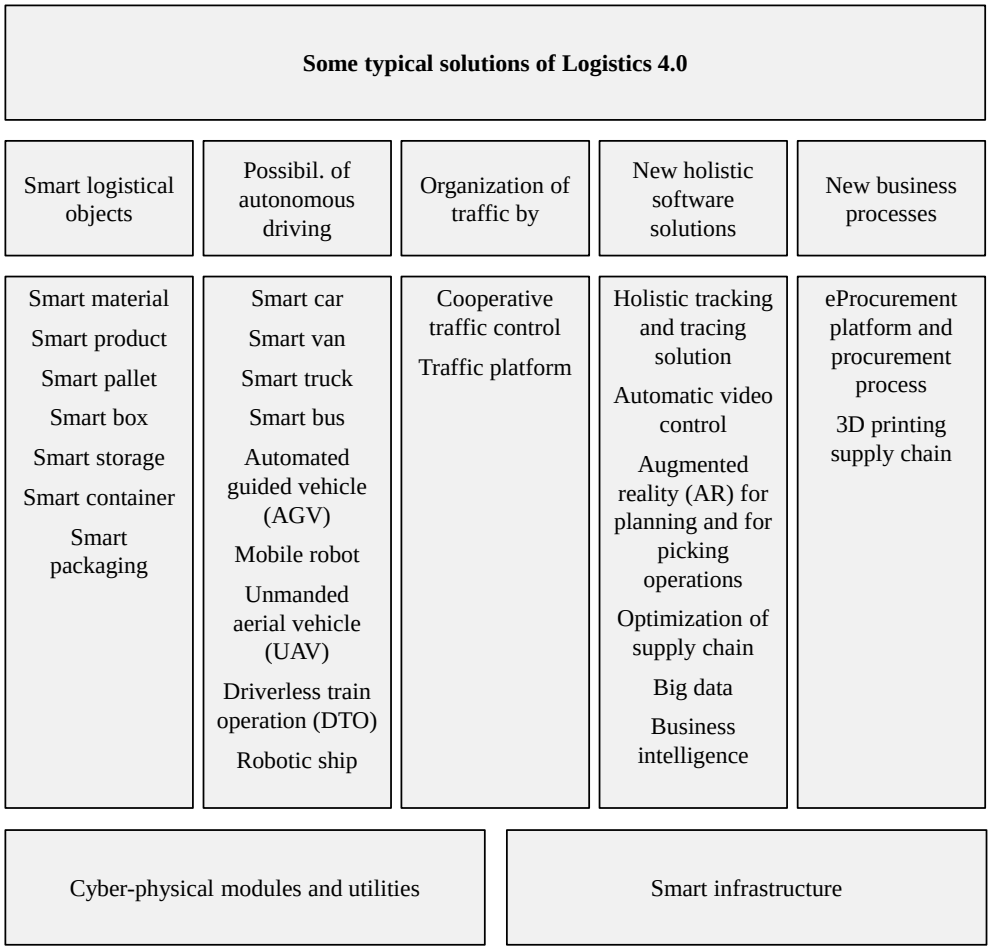

Figure 2. Some typical solutions of Logistics 4.0 (Compare [14] [15])

New models of AGVs and mobile robots use more sensors to get more information, drive autonomously and communicate with each other. They navigate by themselves to places where they are needed. They support e.g. transportation and delivery processes, handling of tools and parts, assembly, quality control and maintenance. The newest solutions of UAV and the self-positioning of trains are also part of Logistics 4.0. (Compare [8]) Robotic ships will have robots, cameras, sensors, radar, sonar and GPS onboard. The navigation is autonomous but could also be centrally controlled. For more information see [9] [10].

Organization of traffic by the cooperative traffic control is based on the recording of the current traffic situation and the adaption of traffic signs and signals while the traffic platform interconnects the intermodal transport and the intermodal movement.

Telematics solutions use technical data to optimize fleet management, vehicle management, driver management and cargo management.

New holistic software solutions (with CPS characteristic) allow new processes. Tracking is useful for position fixing and for the delivery status of the object. Tracing allows a holistic view on the value added chain. Video control is used for documentation, for security tasks and for control of logistics processes. The video sequences are automatically checked and give signals and/or actor activities as reaction to abnormal situations. AR helps to increase the process quality by avoidance of logistical failures and by increasing the efficiency of staff by avoidance of unnecessary searching processes. SCM allows the identification of possible savings and the avoidance of effectivity losses in the framework of a holistic consideration. Big data are based on data analysis methods to discover patterns and other useful information. BI are "the processes, technologies, and tools needed to turn data into information, information into knowledge, and knowledge into plans that drive profitable business action. Business intelligence encompasses data warehousing, business analytic tools, and content/knowledge management." [11]

New business processes realize the business-to-business or business-to-consumer or business-to-government purchase or the new 3D-printing process. New solutions of Logistics 4.0 realize the full process in the kind of a sensor triggered, software integrated, autonomously realized and optimized process. One more example are the freight exchange to conclude sub-contracts and to reduce empty runs. Software helps to realize process mining, Business Activity Monitoring (BAM), Business Operations Management (BOM) and Business Process Intelligence (BPI).

Some typical Cyber-physical modules and utilities are smart shelf, shelfs with robots, modular cross-linked conveying systems, robot assistance, smart clothes, data glasses, data gloves.

Smart infrastructure are e.g. smart docks, smart gates or smart ramps. They allow different logistics processes and systems.

According to Fig. 2 we can differ into three levels of Logistics 4.0 realization. Single cyber-physical solutions (CPS) are members of the first level. Holistic cyber-physical systems are members of the second level. New business visions and business processes with CPS are members of the third level.

Now we can also answer the question, if there are any successful realized solutions, which optimize logistics at a whole. The majority of solution in fig. 2 will only change the fulfilment of existing processes, but some of them will also create new business processes.

3. TARGETS AND MEANS OF INBOUND LOGISTICS IN LOGISTICS 4.0

Which requirements on logistics management will exist according to the criteria of Industry 4.0/Logistics 4.0?

Tab. I shows the targets and means using the example of inbound logistics according to the Industry 4.0 philosophy.

The question is the following: Are the classic logistics strategies still valid according the digital transformation process?

Table I.
Targets and means of inbound logistics according to the Industry 4.0 philosophy [6], p. 100

Organizational targets	**Process-related targets**	**Economic targets**
- Simplification of organization - Liquidation of inflexible links - Integration of suppliers in the IT - Liquidation of the operative procurement - Extension of the supplier portfolio	- Decrease of inventory - Increase of security of supply - Increase of adherence to the delivery dates - Increase of flexibility - Self-control of procurement - Completely digitalization and autonomy - Increase of the transparency	- Decrease of acquisition price - Decrease of process costs
by - Interdisciplinary cooperation - Vertical and horizontal integration - Integrated ERP systems (Big data, Cloud Computing)	by - Administration of complete parts list, raw materials and supplies in data bases - Digitalization of processes by Cloud Computing, Big Data services - Integrated ERP-systems - automated purchase requisition	by - Multiple Sourcing strategies - full imaging by software - outsourcing of services

4. LOGISTICS CONCEPTS AND LOGISTICS 4.0

Most logistics concepts are well known in the logistics science, like e. g. Just in time, Quick Response, Continuous Replenishment, Hub and Spoke, Channel Management, Vendor Managed Inventory, Cross Docking, Efficient Consumer Response, Collaborative Planning Forecasting and Replenishment, Electronic Market, Tracking and Tracing, Supply Chain Management, 1PL- 5PL, Sourcing strategies (Sole, Single, Multiple, Local, System, Modular, Forward, Global), Milkrun, Kanban, Conwip. (Compare [12] p. 3).

Eight of these concepts were intensively reviewed concerning their appropriateness to Industry 4.0 and Logistics 4.0. These are Kanban, Single and Multiple Sourcing, Milkrun, JIT, Quick Response, Continuous Replenishment and Vendor Managed Inventory. (Compare [6])

In [15] this was be answered using the example of Kanban. Logistics concepts always have a strategic orientation and use special methods and tools to achieve the strategic tar-

gets. The traditional Kanban method is a simple control loop operated by self-organization, pull principle and a small security margin. Kanban is realized in a great variety of solutions. The modern Kanban principle is now often used on an electronic base as eKanban. The eKanban is a computer-based, alternative application of the traditional Kanban method. The physical card is replaced by logical parts and orders in a data processing system. The material flow is synthetic calculated by considering customer demands and inventory data. (Compare [13] p.551). The responds to the previous question is that the Kanban strategy has a still revalidation but in a modified form. Digitalization and globalization change the sourcing organization in the companies. Changes of the global organization, the management of the commodity groups and the integrated cooperation are examples.

4.1. Single Sourcing

The success of a single sourcing strategy depends on the reliability of the supplier. The strong dependence on only one supplier is a negative aspect.

The risk of non-performances increases. Single sourcing strategies prevent technological innovations and reduce times to market in the most cases.

Reduced flexibility and missing competition are negative aspects when approaching the Industry 4.0-concept. The necessity to realize a technological progress represents a conflict for the single sourcing strategy. This strategy also has strict validity limits.

Single Sourcing components are often important strategic parts for the company. There are to supply a great number of parts. The processes are organized by using the philosophy of Just-in-time or of Just-in-sequence. A single sourcing strategy is also useful to procure C-parts, because there is no common development work necessary while reducing material costs.

4.2. JIT

Just-In-Time-strategy has a positive influence on achieving the goals of production logistics according to Industry 4.0 requirements. The JIT-philosophy supports the flow idea and the kind of implementation of future technologies and processes in the Industry 4.0 age. The pursuit of holistic CPPS is supported by the strong integration and permanent cooperation with suppliers. This requires standards in integrated IKT-systems as well as common used physical technics. The vision describes a self-controlled system that operates in a network with other systems. The JIT-strategy is still valid.

4.3. Quick Response (QR)

The main idea of QR is the automation of the supply chain between supplier and purchaser by using IT applications. The contents of QR enhance the JIT concept. The enhancements are related to optimized networks and automated processes between companies and their suppliers. That is why there is a big intersection between the fundamental ideas of Industry 4.0-and the QR-theory. QR is still valid.

4.4. Continuous Replenishment (CR)

The CR strategy realizes a cooperative, automated recall system. CR is the next level of Quick Response according to complexity and effectiveness. QR demands data exchange. Continuous replenishment changes the roles. The CR strategy is still valid.

4.5. Vendor Managed Inventory (VMI)

VMI-partnerships require a high level of cooperation, much more than data exchange means. VMI-partnerships have advantages for both companies. The supplier can reduce costs, producing companies can operate flexible due to current market conditions and trends. They can guarantee an agreeded service level. Most of the process triggered requirements of Industry 4.0 are fulfilled. The organizational structure is simpler than before due to outsourcing of processes. The VMI is still valid in a more comfortable kind.

4.6. Milkrun concept

The milkrun concept is often used in intralogistics. The concept is reviewed in the area of procurement logistics in this paper. The costs of logistic activities have a big influence on the price of products. The milkrun concept helps to optimize sourcing and transportation processes. This optimization will be pushed further by Industry 4.0 concepts. Intelligent logistical objects, networking and implemented, integrated IKT-systems can considerably improve the milkrun-processes. The digitalization simplifies the planning of the closed loop. The processes will be more transparent than before. The milkrun-concept is still valid and will permanently increase in the future.

5. THE VALIDATION OF MULTIPLE SOURCING STRATEGY

Table II analyses how the Multiple Sourcing Strategy supports the targets of inbound logistics in the sense of Industry4.0/Logistics 4.0.

Logistics concepts have always a strategic orientation and use special methods and tools to achieve the strategic targets.

Multiple Sourcing: A multiple sourcing concept is a good possibility for companies to spread the demands. This creates permanent improvement process though competition. The strategy is characterized by independence from suppliers. The company can use different options. No delivery bottlenecks should exist. The company is able to respond with a big flexibility. Thereby the concept has a regional, national or also global dimension. Multiple sourcing processes control a great number of markets on a wide base and the corresponding enhancements too. It is also possible to get short-term profit where possible. The digitalization is a big chance to facilitate watching the markets, proofing and adapting contracts, realizing supplier validations and the whole communication and information process. Multiple sourcing signify a great flexibility, but also more expenses to take care of all suppliers. An automatic e-procurement simplifies the processes and is able to react fast to different conditions. This strategy is still valid and will permanently increase in the future.

Table II.
Analysis of targets of the inbound logistics in Logistics 4.0 by using Multiple Sourcing Strategy (Compare [6], p. 108)

TARGETS OF INBOUND LOGISTICS (LOGISTICS 4.0)		**MULTIPLE SOURCING STRATEGY**	
ORGANIZA-TIONAL TARGETS	Simplification of the organization	-	High expenditure for information and logistics
	Liquidation of in-flexible links	++	The vertical integration is supported by technological innovations
	Integration of sup-pliers in the IT	+	Integration in IT is absolutely necessary
	Extension of the sup-plier portfolio	++	Commitment of several suppliers
PROCESS- RELATED TARGETS	Decrease of inventory	+	Ordering of small batch sizes
	Increase of security of supply	+	Small risk by variation of suppliers
	Increase of adherence to the delivery dates	0	Defaults are possible, but variation of suppliers
	Increase of flexibility	++	By integration of several suppliers with slack links
	Self-control of procurement	0	More expenditure than Single Sourcing has, but Industry 4.0 technologies are possible
	Completely digitalization and auton-omy	++	Requirements for the use of effective Multiple Sourcing
	Increase of the transparency	+	Full integration in IT
ECONOMIC TARGETS	Decrease of acquisition price	+	Advantages by competition, but higher costs by missing quantity discount
	Decrease of process costs	+	Still high costs by high expenditure for information and logistics

- NEGATIVE IMPACT
0 NO IMPACT
+ POSITIVE IMPACT
++ HIGH POSITIVE IMPACT

6. CONCLUSION

This paper gives an overview about the basics and ideas Logistics 4.0. The paper answers the following four questions of research: (1) Are there typical solutions of Logistics 4.0 known? There are seven groups of solutions of Logistics 4.0 characterized in table 1. (2) Are there any successful realized solutions, which optimize logistics at a whole? There are only some new solution which create new business processes. The majority of solutions change the fulfillment of existing processes in the sense of process improvement by using elements of CPS. (3) Which requirements on logistics management will exist according the criteria of Industry 4.0/Logistics 4.0? Therefore Table 2 shows the targets and means using the example of inbound logistics according the Industry 4.0 philosophy. This is a combination of a lot of well-known targets from the Industry 3.0 area and only some new considerations. (4) Are the classic logistics strategies still valid according the digital transformation process? Eight logistics concepts were intensively reviewed according their appropriateness in the sense of Industry 4.0 and Logistics 4.0. (Compare [6]) The paper shows the results of the Multiple Sourcing Strategy. The Multiple Sourcing strategy is still valid in the sense of Logistics 4.0 but in a modified, holistic, computer-integrated form.

References

[1] Behrendt, F., Poenicke, O., Schmidtke, N. & Richter, K. (2018). The Smart Logistics Zone as an enabler of Value-added services in the context of Logistics 4.0. *ISSL Symposium of BVL*

[2] Huber, W. (2016). *Industrie 4.0 in der Automobilproduktion. Ein Praxisbuch.* Springer Vieweg. Wiesbaden. https://doi.org/10.1007/978-3-658-12732-9

[3] Kagermann, H., Lukas, W.-D. & Wahlster, W. (2011). *Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. Industriellen Revolution.* Retrieved from VDI-nachrichten.com.

[4] BITKOM Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e.V./VDMA e.V.; /ZVEI e.V. Zentralverband Elektrotechnik- und Elektronikindustrie e.V. (Hrsg.) *Umsetzungsstrategie Industrie 4.0 – Ergebnisbericht der Plattform 4.0.* (in German). Retrieved from https://www.bitkom.org/Bitkom/Publikationen/Umsetzungsstrategie-Industrie-40.html.

[5] Hausladen, I. (2014). *IT-gestützte Logistik. Systeme - Prozesse - Anwendungen*. Second, total revised and enhanced edition. Springer Gabler. Wiesbaden. https://doi.org/10.1007/978-3-8349-4665-2

[6] Ott, S. (2017). *Industrie 4.0 und die Anforderungen an das Logistikmanagement sowie die Gültigkeit bestehender Logistikstrategien*. Master thesis. Otto von Guericke University Magdeburg. Faculty of Mechanical Engineering. Glistau, E. (Adviser).

[7] Sonnenberg, V. (2017). Mobile Roboter in der Fertigung. Maschinenmarkt. *Das Industriemagazin. 16*. 20-23.

[8] Randelhoff, M. (2016). *Automatisierter Bahnbetrieb und führerlose Züge: Eine Einführung (Technik, Vorteile, Hürden, Umsetzungszeitraum***)**. Retrieved from www.zukunft-mobilitaet.net/90799/

[9] Hänssler, B. (2014). Unbemannte Roboterschiffe: Geisterschiffe mit Containern. *In: Spektrum – Die Woche. 15. KW 2014*. Retrieved from www.spektrum.de/news/roboter-frachtschiffe-geisterschiffe-werden-realitaet/1281597.

[10] Unbemannte Riesenfrachter, Japan will Roboterschiffe einsetzen. *Spiegel online*. Retrieved from http://www.spiegel.de/wirtschaft/unternehmen/japan-will-unbemannte-riesen-frachter-bauen-a-1151143.html.

[11] Loshin, D. (2003). *The Data Warehouse Institute Faculty Newsletter*. Fall 2002 as cited in Business Intelligence: A Savvy Manager´s Guide. Maryland Heights. MO: Morgan Kaufman Publishers. https://doi.org/10.1016/B978-155860916-7/50003-8

[12] Völker, R. & Neu, J. (2016). *Supply Chain Collaboration - Kollaborative Logistikkonzepte für Third- and Fourth-Tier-Zulieferer*. Physica-Verlag Heidelberg.

[13] Dickmann, P. (2016). *Schlanker Materialfluss- mit Lean, Kanban und Innovationen*. Springer Vieweg. 3. edition. https://doi.org/10.1007/978-3-662-44869-4

[14] Glistau, E. & Coello Machado, N. I. (2018). Industry 4.0, Logistics 4.0 and materials - chances and solutions. In: *Novel trends in production devices and systems IV: NTPDS IV;* Special topic volume with invited peer reviewed papers only - Zürich: Trans Tech Publications, S. 307-314, Retrieved from http://dx.doi.org/10.4028/www.scientific.net/MSF.919.307; [Materials science forum; 919]

[15] Glistau, E., & Coello Machado, N. I. (2018). Logistics 4.0 and the revalidation of logistics concepts and strategies. *In: MultiScience - XXXII. microCAD International Multidisplinary Scientific Conference:* University of Miskolc, Hungary 5-6 September, 2018 - Miskolc: University of Miskolc, Hungary, insges. 8 S. https://doi.org/10.26649/musci.2018.023