THE IMPORTANCE AND EFFECT OF INNOVATION AND 4.0 INDUSTRIAL REVOLUTION ON LOGISTICS

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Abstract
The main aim of the article is to present the impact of innovation and benefits of implementation of Industry 4.0 solutions in logistics. The adoption of new technologies and digitization directly linked to Industry 4,0 will affect all of us, will support the change of the business nature as well as business models. Based on the above mentioned, the Industry 4.0 will affect all areas in the business, and logistics is one of them. Logistics can be considered as an area which still provides a sufficient space for the benefits resulting from the implementation of advanced technologies and play important role in the era of globalization. It is important for businesses to realize the importance of innovation and smart solutions that will not only represent a competitive advantage in the future, but also a source of their survival.
The article contains theoretical background of the term innovation and the connection to logistics as well as specific examples of innovative solutions and implementing Industry 4.0 solutions in logistics and its advantages. The author of the paper present selected issues connected to innovations which allow many companies to improve their market position.

Keywords**:** *innovation, smart solutions, logistics*

INTRODUCTION

In the changing market managers have to use modern methods, techniques and ideas of management. The authors pay special attention to the need for efficient communication, both inside of organization and with co-operating companies. The aim can be realized thanks to modern information technology. It could play the key role in connecting the engineering knowledge with the economical effectiveness represented by the managerial board.

The cooperation, collaboration and competition between engineers and managers should stimulate invention and innovation. To stimulate invention and innovation within logistics we have to pay careful attention to education. New knowledge in the field may be gleaned from practical experience or generated through systematic research and development, and is reflected in gradual modifications and improvements, or in more extensive and radical logistics innovations.

In the era of globalization, a very important role is played by logistics. This applies not only to the functioning of individual companies but also to national economies and even the world economy. The phenomenon of competition can now be observed not just in individual companies but entire supply chains. The pace of development of the modern economy means that companies are forced to constantly introduce more and more new solutions, resulting in innovation driving the progress of the market. Enterprises are competing in the search for innovation in the logistics market, and thus technologies are developing at a dizzying pace.

1. INNOVATION

Innovation today is synonymous with progress and modernity in every area - from the social sphere, through the educational system, to the economic sphere in science and economy, looking for new solutions that contribute to competitive advantage in the market and

thus raise the level of economic and social development and ensure a high quality of life. *"Innovation is the difference between leaders and followers,"* S. Jobs, Apple's famous CEO (Raport, 2016). The confirmation can be seen in the Figure 1, which shows that most of projects based on innovation and high technologies are implemented in the United States (US) and thus the US economy is leading the world economy.

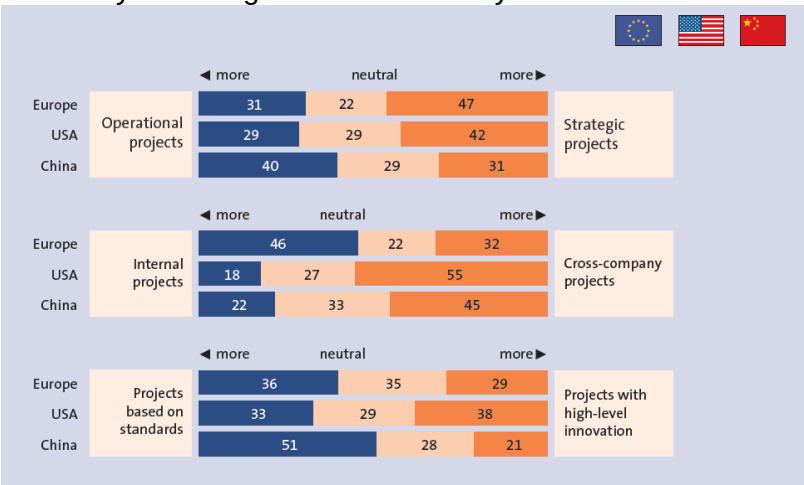

***Figure 1**: Project agenda of "Leaders": Strong focus on strategic, cross-company, and innovation projects (Trends and Strategies in Global Logistics Networks, 2010)*

The European Union (EU), in order to reduce the gap between itself and the US in the area of economic development, requires an industrial and technological base to provide the citizens in the EU and beyond its borders solutions for communication and movement in increasingly urbanized areas (Witkowski, 2009; Witkowski, 2011).

The concept of innovation comes from the Latin 'innovare' or 'creating something new'. The concept of innovation was introduced to world economic literature by J. A. Schumpeter in 1912; he treated innovation as a factor in economic development, and its inclusion is considered a classic. According to J. A. Schumpeter (1960), innovations are new combinations which occur in the following cases:

- Developing a new product or introducing products with new properties to the market,
- Introduction of a new method of production,
- The opening of a new market,
- Acquisition of new sources of raw materials,
- Carrying out a new organization of economic processes.

The definition is the starting point for a discussion about the importance of innovation in the economy. In terms of J. A. Schumpeter's definition, where innovation means putting new solutions into practice, the author focused primarily on technical innovation and its impact on the economy. He is the creator of the so-called concept of "Creative destruction", which is a continuous destruction of old structures and the constant development of new, more effective ones. For P. F. Drucker (Innowacja i przedsiębiorczość. Praktyka i zasady. 1992), in turn, *"Innovation is the specific tool of entrepreneurs, by means of which the changes make them an opportunity to take up a new business or the provision of new services".* In his opinion, *"innovation does not have to be technical, it need not even be something material".* Yet another definition of innovation can be found in the Operational Programme Innovative Economy, where innovation is understood as putting into practice new or significantly improved solutions regarding a product (good or service), process, marketing or organizational system within a company.

There are many definitions of the concept of innovation, however all boil down to determining that innovation is a process and not something that occurs in the short term. It is a process during which something completely new or improved is created, or which transforms

something which already exists. It could be stated therefore that it is a consequence of the progress of the processes of science and technology. Innovative strategies can raise also the level of logistics customer service and logistics services, thereby enhancing the work and its conditions. This results in the shortening of customer service times, and a consequent increase in demand for such services.

1.2 INNOVATION IN LOGISTICS

Innovation and time are the main competitive advantages within logistics (Zalewski, 2011). Time is understood as the frequency of the introduction of new or significantly upgraded versions of the product. Its growth changes and shortens the life cycle of such products in comparison to conventional products. The different phases of the life cycle are short in-time and rapid demand-dimension, which is changing the nature of modern logistics (Zalewski, 2015).

A consequence of the booming market, which is set up to meet increasing customer demand, has led to changes in the organization of the enterprises. The most important are shortening product life cycles (Example: The first generation Volkwagen Golf (VW) was produced in the period from 1974 until 1983 (convertible version of VW Golf until 1993, and Caddy van until 1992, while in South Africa the car was produced continuously until 2009). The latest (sixth) generation of VW Golf was produced from 2008 to 2012 (only 4 years)). On the other hand, extensions to the range can be seen (Example: cars of the same model are offered with many variations in engine, bodywork and equipment; all this in order to better meet the needs of increasingly informed and demanding customers). In the specific race for customer acquisition companies are seen to offer newer products but with a lower level of quality than the previous versions, phenomena that is especially noticeable is the consumer goods market. Above mentioned leads to the creation of simpler, cheaper and more attractive products for the less affluent and less prepared customers. From this premise, it can be assumed that the life cycle of that product will be shorter than its earlier versions. Such products are technologically excellent and good value; however, their shelf life is limited. It is this new model of production this presents a huge challenge today in all three areas of sustainability, creating demands in the economic, social and environmental spheres. Such market changes have led to the appearance of the phenomenon of disruptive innovation (Zalewski, 2010).

To be successful in today's logistics, the implementation of modern technologies is a prerequisite. Organizations without information systems, automation and electronic data interchange have no chance to participate in modern forms of business. Considerable effort is therefore required on the development of logistics companies or outsourcing, or the transfer of logistics management to specialized entities who holds adequate technologies (Bednarowski, Kramarz, 2006).

In an attempt to clarify the nature of the concept of logistics technologies, it should be noted that it is a particular case of technology, which, whilst located within the general definition of technology, is specifically a set of tools and procedures in the process of the movement of goods and persons, and in the activities supporting this process. In practical terms, logistics technologies are nothing but information systems supporting logistics (e.g. Systems of identification, communication technologies, Internet) and procedures in the process flow such as the Just-in-time system, methods of loading, container systems, transport technologies, methods of packaging, storage, etc. In relation to industrial technologies, logistics is characterized by: large scale, diversity, complexity, variability and non-specificity (Długosz, 2009).

The objectives pursued by logistics technology focus consistently around facilitating the company to perform various logistics tasks, shortening their duration, reducing costs, maintaining quality interchanging and storing goods, etc. Any technological improvements that create a new quality of logistics processes are the essence of innovation in this field.

Logistics in all aspects requires constant and thorough improvement, and this is achieved mainly through the use of knowledge, competence, experience and what is widely understood as the intellectual capital of the organization. Appropriate management is a key strategic area for an enterprise wishing to innovate in logistics. Logistics managers should have a creative inventiveness and creativity, with the greatest benefits being the ability to recognize and exploit the wisdom and commitment of the entire team of employees of the company. A necessary complement to the emerging climate of innovation within enterprise is adequate support technologies. With their help it is possible to create and use databases for innovative logistics and management projects (Szymonik, 2004).

Innovation in logistics is not, however, solely associated with the involvement of modern IT solutions. A sign of modernity can also be a way of thinking. Innovative solutions in logistics can also manifest themselves in (Doskonałość w logistyce, 2010):

- continuous improvement of a team carrying out innovation and continuous verification of work and commitment,
- constant vigil over the quality of activities,
- constant focus on work of the team which is working on the implemented practices and shared values,
- activities involving the constant search for new and better ways to implement the tasks of logistics,
- satisfaction with work and honesty to customers, elimination of old habits, behaviors and barriers associated with changes in the area of logistics activities.

It follows that the most important drivers of innovation that somehow push companies to create new value in logistics are human resources and organizational culture.

As well as citing two breakthrough innovations in logistics, namely the container, which has totally revolutionized the flow of materials and RFID technology, which has contributed to the transparency of the supply chain, Pfohl also mentions other key success factors:

- the structure of regional networks, flexibility, risk management and rotation means,
- increased customer requirements in terms of lead time delivery services, their availability and reliability,
- services prepared in accordance with the needs of consumers, therefore rapid response to their needs,
- segmentation of the supply chain focused on demand and specific needs of customers, which can help to reduce the volume of stocks, and thus - to optimize costs,
- safety requirements and potential hazards in the supply chain,
- risk management in the supply chain,
- strategies for sustainable development of enterprises with regard to environmental aspects.

All of the above mentioned factors and trends should be reflected in innovative logistic solutions. Thanks to economies of scale they will be able to lead to solutions that allow logistics operators to meet the requirements of consumers in the twenty-first century.

An example of innovative solutions in the warehouse can be seen in the STILL Company, which has introduced iGo neo CX 20 series autonomous vehicle to the production line. The truck has software and sensors, so that it becomes part of an intelligent intralogistics process. Thanks to sensors and laser environment detection system, the iGo neo CX 20 can analyze the topography of the warehouse rack location, user location, and other traffic participants in real time. The iGo neo CX 20 application allows the truck to be automatically operated, adapting to the rhythm and completely freeing it from the need for an operator to control the vehicle. This device has a system for obstacle detection and recognition system for panoramic surroundings, which with the help of a laser scanner registers the position of objects around the truck 84 000 times per second (www.still.pl, 2016).

2. THE INTERNET OF THINGS

The concept of the Internet of Things (IoT) was created by a British entrepreneur and founder of start-ups named Kevin Ashton. The idea was formulated in 1999 to describe a system in which the material world communicates with computers (exchanges data) with ubiquitous
sensors. Almost a decade later, at the turn of 2008 and 2009, the number of devices connected to the network exceeded the number of inhabitants of our globe. This moment, according to Cisco, is the true birth of the "Internet of Things", referred to more often as the "Internet of Everything". In this approach, a system is created not only of objects but also the processes, data, people, and even animals or atmospheric phenomena - everything that can be treated as a variable (Raport, 2016).

Three distinguishing features of the IoT are context, omnipresence and optimization. The first refers to the possibility of an advanced object interaction with an existing environment and the immediate response by it to change. The characteristic of context allows objects to provide information such as location, physical condition or atmospheric conditions. Omnipresence illustrates the fact that objects today are much more than just connections to a user network of human-operators. In the near future, they will communicate with each other on a large scale. Optimization is the expression of the functionality which every object possesses.

To fully understand the scale of the phenomenon and the number of devices that can be found within the IoT, a list of potential areas where the use of IoT solutions can be seen, according to the classification adopted by O. Vermesan and P. Friess (2014) is as following:

– Smart/Intelligent industry is entering the area of the IoT in solutions related to particular sectors of the national economy. Possible areas of application are the monitoring of the state of stocks (e.g. the state of reserves - water, fuel, gas) through to: solutions silo (filling level of storage and weight of stored goods), diagnostics (e.g. auto-diagnostic equipment, system failure detection), working conditions (e.g. monitoring inflammatory and dangerous gases, temperature) or processing of products (e.g. the detection of ozone levels, particularly important in plant foods).

– Smart/Intelligent production as well as intelligent industry, includes solutions that fall within specific sectors of the economy. These are both issues related to agriculture (e.g. Temperature control and irrigation to prevent drought or the formation of fungi), breeding (monitoring living conditions and grazing livestock), and control of production lines (readers, sensors, video surveillance - useful in the management and inspections) as well as control of the rotation of products on store shelves and in warehouses.

– Smart/Intelligent transport - a key element of supporting the economy. This category includes issues such as: the location of transported goods (e.g. checking routes of hazardous, delicate or precious materials) control of the conditions of transport (e.g. shock) or storage conditions (e.g. flammable materials). IoT also enters into issues related to the organization of transport, which includes for example hotel booking style sites for charging stations for electric vehicles, automatic tolls in congested areas and self-diagnostics. This manner of exploiting the benefits of the IoT can be critical for car rental fleets, and even defense systems. Its role should also be emphasized in the NFC (Near Field Communications) payment system - in transport and utilities.

– Smart/Intelligent cities is another area in which the IoT can play an increasingly important role. Its capabilities promise a lot of applications - from the organization of pedestrians and traffic (e.g. monitoring traffic congestion, parking spaces, intelligent roads), the diagnosis of safety threats (e.g. vibrations and strength of materials in buildings, noise, lighting (e.g. adaptive to the level of cloud cover) and waste management (e.g. filling level of containers).

– Smart/Intelligent buildings - monitoring the property (e.g. fences, windows, doors), motion sensors, smart irrigation, learning thermostats.

– Smart/Intelligent apartments is a category of equipment, which are typically for individual application (e.g. refrigerators (informing content, shelf life, the need to replenish), remote machines (allowing use of energy at lower tariffs), and cookers (for remote setting of the oven). With solutions in this category, it is possible to control utility consumption (by controlling light bulbs, thermostats, air conditioning) and security (surveillance child, camera, alarm).

– Smart/Intelligent health covers a wide range of applications used in the monitoring of health and physical activity (the elderly), vitality (people active in sport), patient safety (both in hospital and at home), sleep control (intelligent mattresses). For applications at the industrial level for the monitoring of hygiene (e.g. to inform about the need for hand washing stations), the state of goods (e.g. monitoring of medical refrigerators) and security (e.g. the level of UV radiation in nuclear power plants).

– Smart/Intelligent life is a whole range of consumer solutions aimed at comfort and safety. These include: support for purchases (compliance with the habits, monitoring the presence of allergenic components, expiration date, etc.), remote control equipment to avoid accidents, monitoring weather conditions (temperature, humidity, atmospheric pressure, wind strength and rain) and protection of personal property (wallets, jewelry)."

– "Smart/Intelligent environment is a category of solutions, IoT, which from the daily consumer perspective are the least visible. The smart/intelligent environment includes, for example: automated systems for monitoring current status and estimating the probability of natural disasters (e.g. risk of fire, earthquakes), control of air pollution (CO2 emissions), life protection of wild animals (e.g. tracking them via GPS / GSM) or tourism.

– Smart/Intelligent water management, a wide range of issues related to the administration and management of key resources for the functioning of the environment. This category includes: The impact of water resources on the environment, their use and protection deficits, regulation of rivers and protection against floods, waterways, hydropower or security. With such solutions, the IoT offers the possibility for live management of the process of water supply, starting from the control of its suitability for consumption and storage, through supply and water supply tightness, after monitoring the consumption of end users.

– Smart/Intelligent energy includes a number of solutions that enable management of utilities. These include the monitoring of individual consumption, as well as the processes for its production and use (e.g. solar systems, windmills and water management).

2.1. EXAMPLES OF APPLICATIONS OF THE INTERNET OF THINGS IN LOGISTICS

The IoT offers new possibilities in the area of performance (example: road transport trucks can be automatically controlled to the specification of hosts, which will allow them to operate in predefined intervals and with a standard speed, so as to maximize fuel economy). Other examples are as following: The Daimler Group has invested in the development of mobile services such as car2go, myTaxi or moovel. General Electric, likewise, has invested in systems to operate equipment and factories use a system called "Industrial design" (Internet industry). Company LG is preparing for "smart homes", producing televisions and household appliances which can connect to the Internet, enriching the offer of related services (Perera, 2015). There is also increasing pressure for utilities suppliers to introduce smart metering, currently led by the UK (Department for Business, Energy & Industrial Strategy).

Based on the above mentioned, transport is one of the potential areas where the use of IoT solutions can be seen and nowadays several solutions have been already developed. These include the delivery of parcels to the boots of cars belonging to the recipients. Such solutions have been implemented by Audi, Volvo, Amazon and DHL. Through the use of appropriate systems, deliveries can be supplied directly to the car, even when it is locked. By using appropriate technology, the couriers themselves can track down customers' vehicles. The driver receives a one-time access code that can be used at certain times. Late arrival

requires waiting to generate a new sequence number. A special digital key allows a courier to open the boot and leave the package intended for the owner of the vehicle.

With the IoT it is possible to supervise the process of travel of packages and letters. Continuous monitoring allows the question "where is my package?" to be eliminated. In case of delay, the customer can be informed in advance of complications. These developments can also be used to reduce wasted journeys related to unsuccessful deliveries and consequently improve the environmental performance of logistics at the consumer level.

In the case of storage in warehouses, intelligent shelving and pallets will become the driving force of modern inventory management. In respect of the carriage of goods - tracking and tracing becomes faster, more precise, predictable and safe. The analysis associated with the development of "connected fleet" can help predict failure and automatically plan moves aimed at improving the supply chain.

The results of the research conducted by Forrester Consulting (2014) on behalf of Zebra Technologies are as following (Adamczewski, 2015):

- nearly 90 % of companies from the logistics and transport sector have already implemented or will implement IoT solutions in the coming year,
- more than 50 % of the respondents expect that the IoT will improve the supply chains,
- 40% of the respondents expect that the IoT will help companies increase their level of safety and cost-effectiveness,
- key technologies in the implementation of the IoT are assumed to be Wi-Fi connectivity, security sensors, NFC communications (Near Field Communications)
- nearly 40 % of the respondents expressed the concerns about the privacy and security of information as the biggest obstacle to the implementation of IoT solutions,
- 38 % indicate a high degree of complexity of these solutions, and as such - a high risk of implementation.

Above mentioned results indicate a challenge, as the IoT is important for the logistics and transport sector. Solutions in the field can provide operational data on the location and monitoring of the condition of things. With the information, it is possible to improve customer service by shortening the cycle of logistics processes and optimizing the cost.

Example: Groundbreaking use of IoT has been seen in South Korea, which has built from scratch the first genuine smart city in the history of the world. This is the South Korean city of Songdo, formed on an artificial island created at a cost of over $40 billion. This city will owe its intelligence system millions of sensors designed by Cisco and present wherever possible: on the streets, in schools, office buildings, hospitals, factories, and in "normal" homes. This city of the future has become the new Korean business capital, just over an hour away from Seoul. The work has already exceeded the halfway point and it can be argued that a smart city will usher in the trend of ultra-modern business cities, which, thanks to IoT and Big Data analytics data will indicate the direction in which the next metropoles will follow (Innovation has the smart city of Songdo living in the future). In addition to the spectacular design of the Koreans, other projects based on the IoT have already been created. The first is Los Angeles, in which the city uses the data sent by the magnetic sensors placed on streets and sensors to monitor traffic. They communicate with a computer system, which controls 4.5 thousand lights and decides how to direct traffic in the city to relieve congestion. As a result, traffic in Los Angeles has declined by about 16 %, bringing significant environmental benefits (Kate Meis, 2016).

Another example is Long Beach, California, which uses intelligent sensors for water management. For nearly four years California has been struggling with a severe drought, which affects already 98 % of its territory. Thanks to the computerization of the system, it has been able to reduce water consumption by nearly 80 % (Adamczewski, 2015).

3. BIG DATA – THE DIGITAL REVOLUTION IN LOGISTICS

Nowadays, through the rapid development of Internet, such a huge amount of information is produced and collected on a daily basis that their processing and analysis is

beyond the capabilities of traditional tools. However, there is a technology by which we can conduct analysis and that is Big Data. Big Data allows us to quickly and efficiently manage and use this constantly growing (thanks to reaping information from many different sources) database. The discussed technology allows analysis and separation of the important from the less important - helping to draw conclusions and support effective transfer of knowledge to carry out business objectives more sustainably. According to Forrester's definition, Big Data consists of four dimensions (called as 4V) volume, variety, velocity and value (Marketing Automagic, 2013).

Big Data makes it possible to analyze the data at a more advanced level than traditional tools allowed. With the technology, even data which has been collected in various mutually incompatible systems, databases and websites is processed and combined to give a clear picture of the situation in which there is a specific company or person.

The specific example of the use of Big Data technologies in the area of logistics is company DHL, which implemented the so-called "Resilience360". Resilience360 is an instrument designed to manage risk in the supply chain. The company can provide customers with information on potential interference of their respective supply chains. It is through the collection and evaluation of data that it is possible not only to protect, but also to improve the efficiency of the supply chain. Hence, there is no interruption in operations and it is possible to permanently achieve customer satisfaction. DHL demonstrates that the use of Big Data analytics increases operational efficiency, while providing the opportunity to explore new business models. DHL Resilience360 contains two elements that are associated with the risk assessment analysis, as well as tools to monitor the supply chain that work in almost real-time. The strength of the chain and associated revenue losses depend on whether a break occurs in the production, and this should be less prone to failures. DHL is in the pilot phase on the model of "The forecast number of packages DHL", which has also been taken in connection with the analysis of Big Data. The model simplifies the planning volume of parcels for transport - this is done by "taking into account correlated data factors." Big Data enables service providers to optimize logistics processes, improve customer service, and presents "a promising starting point for developing new business models."

Big Data suggests some instruments operating in the field of geomarketing for small and medium-sized enterprises. Another model "DHL Geovista' allows a detailed analysis and evaluation of very complex geographic data to be obtained, which greatly facilitates the logistics service providers to anticipate the multiplicity of sales, which generate small and medium-sized enterprises [Portal gospodarczy, 2014].

Among the sources from the supply system is information from retailers, transport, invoices and more. Data from customer profiles, social networking profiles, orders, market forecasts and geographical schemes also plays a role. Using customer data to analyze information from the delivery system, retailers can meet the expectations of customers by anticipating their behavior.

The new approach to farming known as 'smart farming' is another example of the application of big data within one of the most important supply chains for society (Wolfert, Ge, Verdouwa, Bogaardt, 2017).

CONCLUSIONS

Nowadays, the businesses, including logistics companies, are determined to implement product, technical, technological and organizational innovation. Enterprises are focused on creating value for the customer, who is becoming more aware and demanding in terms of increased customer requirements relating to lead time delivery services, product availability and reliability.

There has been a phenomenon associated with the individualization of products and services - resulting in shorter life cycles, but at the same time an increasingly wide range of

products. Among the trends of development in this area it is possible to point out recovery logistics and reverse logistics.

Access to information is becoming increasingly common. Information technology allows access to the system at a convenient time and place. This changes the image of traditional trade, business, government, education, introducing e-commerce, e-business, e-government, e-learning, and many other solutions. It is important that these solutions are generally widely available, but only their skilful implementation and merging into a single cohesive system will achieve the synergy benefits.

REFERENCES

MEIS, K. 2016. *3 ways IoT is already making cities smarter*, online: https://www.greenbiz.com/article/3-ways-iot-already-making-cities-smarter

ADAMCZEWSKI, P. 2015. *Internet rzeczy w rozwoju e-logistyki organizacji inteligentnych*, Studia Ekonomiczne – Zeszyty Naukowe nr 249 Uniwersytetu Ekonomicznego w Katowicach, Katowice

BEDNAROWSKI, J., KRAMARZ, M. 2006. *Logistyka stosowana – metody, techniki, analizy*, WPŚ, Gliwice

DŁUGOSZ, J. 2009. *Nowoczesne technologie w logistyce*, PWE, Warszawa

Doskonałość w logistyce, wywiad z prof. H.-Ch. Pfohlem, „Eurologistics" 2010, nr 3

DRUCKER, P. F. 1992. *Innowacja i przedsiębiorczość. Praktyka i zasady*. Państwowe Wydawnictwo ekonomiczne, Warszawa 1992. *Innovation has the smart city of Songdo living in the future*. Online: https://newsroom.cisco.com/featurecontent?type=webcontent&articleId=1738492

Marketing Automagic. 2013. *Co to jest Big Data?*. Online: http://marketingautomagic.pl/2013/07/co-to-jest-big-data/

PERERA, Ch., RANJAN, R., WANG, L., KHAN, S., ZOMAYA, A. 2015. *Privacy of Big Data in the Internet of Things Era*, IEEE IT Professional Magazine. Pre-Print (Internet of Anything). Retrieved 1 February 2015

Portal gospodarczy. 2014. *Big Data pomaga firmom logistycznym ograniczać ryzyko*. Online: http://it.wnp.pl/big-data-pomaga-firmom-logistycznym-ograniczac-ryzyko,219495_1_0_0.html 01.08.2016r

Raport: Internet Rzeczy w Polsce, Interactive Advertising Bureau Polska, 2016

SCHUMPETER, J. A. *Teoria rozwoju gospodarczego*, Wydawnictwo PWE, Warszawa 1960

Department for Business, Energy & Industrial Strategy, *Smart meters: a guide*. Online: https://www.gov.uk/guidance/smart-meters-how-they-work

SZYMONIK, A. *Badanie systemów informatycznych wspomagających zarządzanie logistyczne firm*, Logistyka 2004, nr 6.

Trends and Strategies in Global Logistics Networks, VIII. International Logistics and Supply Chain Congress 2010, ISTANBUL, 4th and 5th of November 2010

VERMESAN, O., FRIESS, P. (Ed.). *2014. Internet of Things – From Research and Innovation to Market Deployment,* River Publishers. Online: http://www.internet-of-things-research.eu/pdf/IoT-

WITKOWSKI, K. 2009. *The innovations for sustainable development*, CO-MAT-TECH 2009. Industrial Engineering, Management and Quality for 21st century, 17th International Scientific Conference, Trnava

WITKOWSKI, K. 2011. *Inwestycje infrastrukturalne w realizacji usług publicznych*, Studia Lubuskie, Sulechów

WOLFERT, S., GE, L., VERDOUWA, C., BOGAARDT, M. J. 2017. *Big Data in Smart Farming – A review*, Agricultural Systems 153 69–80, Published by Elsevier Ltd.

ZALEWSKI, R. 2010. *Czy nowe trendy generowania innowacji ożywią współpracę nauka – przemysł*, Marketing i Rynek, nr 12

ZALEWSKI, R. 2015. *Innowacje odwrotne, Towaroznawstwo 2.0 w działaniu na rzecz innowacji*, Wyd. Komisja Nauk Towaroznawczych PAN Oddział w Poznaniu

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