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Procedia Engineering 182 (2017) 763 – 769

Procedia Engineering

www.elsevier.com/locate/procedia

7th International Conference on Engineering, Project, and Production Management

Internet of Things, Big Data, Industry 4.0 – Innovative Solutions in Logistics and Supply Chains Management

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Abstract

The aim of this article is to present some 'smart' solutions which could be recognised as innovative solutions in both areas: technology and organisation. The above mentioned solutions could be implemented by logistics which, in the era of globalization, plays a very important role. This applies not only to 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 in 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. This article is a part of research, which considers the problem of implementation of IT solutions logistics.

Peer-review under responsibility of the organizing committee of EPPM2016

Keywords: Internet of Things; Big Data; Industry 4.0; innovative solutions; logistics

1. Introduction

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", Steve Jobs, Apple's famous CEO, would say [9]. Confirmation of this can be seen in graphs presented in the illustration, which show that most of projects

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Peer-review under responsibility of the organizing committee of EPPM2016
doi:10.1016/j.proeng.2017.03.197

based on innovation and high technologies are implemented in the US and thus the US economy is leading the world economy.

The European Union, in order to reduce the gap between itself and the USA 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 [13, 14].

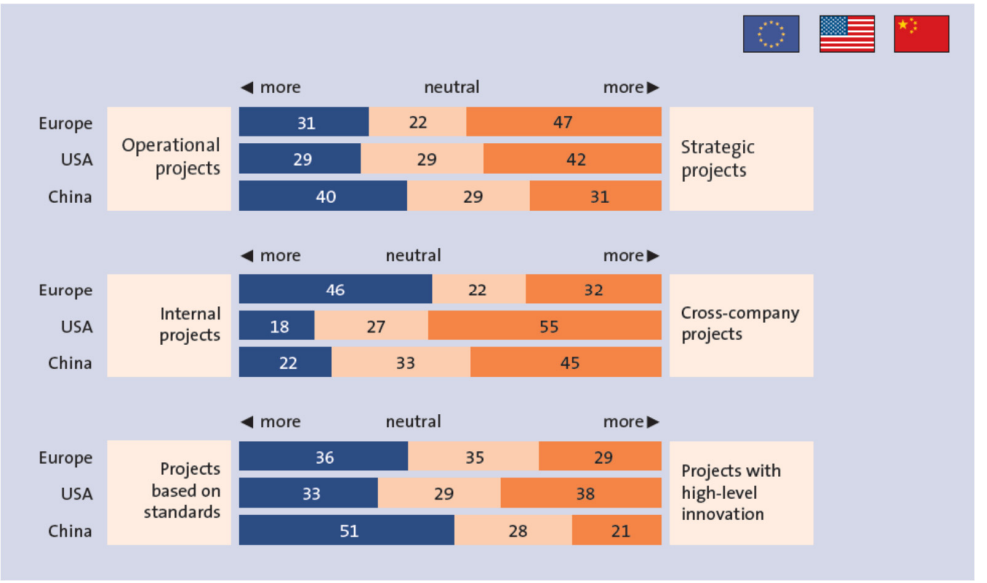

Fig. 1. Project agenda of "Leaders": Strong focus on strategic, cross-company, and innovation projects.

Source: [12].

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 Schumpeter [10], 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.

This definition is the starting point for a discussion about the importance of innovation in the economy. In terms of 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 Peter F. Drucker [5], 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 said therefore that it is a consequence of the progress of the processes of science and technology. Innovative strategies can raise 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.

2. Innovation in logistics

Innovation and time are the main competitive advantages [16]. Time, here, 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 [17].

A consequence of the booming market, which is set up to meet increasing customer demand, has led to changes in the organization of enterprises. The most important are shortening product life cycles. The first generation Volkswagen Golf, for example, was produced from 1974 until 1983. (Convertible version – until 1993, and the Caddy van until 1992, while in South Africa the car was manufactured continuously until 2009). The latest (sixth) generation VW Golf was produced from 2008 to 2012 (only 4 years). On the other hand, extensions to the range can seen e.g. 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 this specific race for customer acquisition companies are seen to offer newer products but with a lower level of quality than the previous versions, a phenomena that is especially noticeable is the consumer goods market. This 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. Such market changes have led to the appearance of the phenomenon of disruptive innovation [16].

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 [4]:

- 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, behaviours 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 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.

3. The Internet of Things

The concept of the Internet of Things 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 [9].

Three distinguishing features of the Internet of things 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 Internet of Things, below is a list of potential areas where the use of IoT solutions can be seen, according to the classification adopted by O. Vermes and P. Friess [9]:

- (Smart) environment is a category of solutions, Internet of Things, which from the daily consumer perspective are the least visible. However, these are the basis for the safe operation of the entire anthropogenic environment (man-made – e.g. Urban, industrial areas, agricultural areas) that make the ecosystem friendly to economic development and the functioning of societies
- (Smart) 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, for example: The impact of water resources on the environment, their use and protection deficits, regulation of rivers and protection against floods, waterways, hydropower or security
- (Smart) industry is entering the area of the Internet of Things in solutions related to particular sectors of the national economy
- (Smart) 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) transport should be – apart from the above mentioned – 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)
- (Smart) 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)
- (Smart) cities are another area in which the Internet Things 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, providing information about the state of roads, traffic problems, monitoring of weather or accidents on the road), the diagnosis of safety threats (e.g. vibrations and strength of materials in buildings, bridges, historic buildings), noise, lighting (e.g. adaptive to the level of cloud cover) and waste management (e.g. filling level of containers).

- (Smart) buildings are a whole range of facilities, which can be used both at the individual as well as industrial level: monitoring the property (e.g. fences, windows, and doors), motion sensors, smart irrigation, learning thermostats
- (Smart) 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), cookers (for remote setting of the oven)
- (Smart) health covers a wide range of applications used in the monitoring of health and physical activity (e.g. the elderly), vitality (e.g. people active in sport), patient safety (both in hospital and at home)
- (Smart) life is a whole range of consumer solutions aimed at comfort and safety.

The IoT offers new possibilities in the area of performance. For 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. 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); LG is preparing for “smart homes”, producing televisions and household appliances which can connect to the Internet, enriching the offer of related services [7].

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.

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. Analysis associated with the development of “connected fleet” can help predict failure and automatically plan moves aimed at improving the supply chain.

According to research conducted in 2014 by Forrester Consulting on behalf of Zebra Technologies [1]:

- nearly 90% of companies from the logistics and transport sector have already implemented or will implement IoT solutions in the coming year
- more than half of respondents expect that the Internet Things will improve the supply chains
- 40% of respondents expect that the IoT will help companies increase their level of safety and cost-effectiveness
- key technologies in the implementation of the Internet of Things are assumed to be Wi-Fi connectivity, security sensors, NFC communications (Near Field Communications)
- Nearly 40% of respondents expressed their 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.

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

4. 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. According to Forrester’s definition, Big Data consists of four dimensions (i.e. 4V):

- Volume (amount of data) – by McKinsey Global Institute, "the concept of Big Data refers to datasets whose size exceeds the capacity of ordinary tools for collection, storage, management and analysis" – it is connected with the technological capabilities to manage these data
- Variety (variety of data) – Big Data comes from a variety of sources, which are: transactional systems, social networking sites or the internet. These data change dynamically and are very unstructured, which means that they are not suited to traditional forms of analysis (they include, for example, images, video and content from social networking sites)
- Velocity (the speed of generation of new data and analysis) – data analysis is carried out on Big Data in near real time, as the correct conclusions from the constantly flowing and changing data need to be implemented on an ongoing basis
- Value (value data) – the general aim is to isolate the whole mass of information to what is most important for us – this is why it is so important that the results reflect the actual conditions and led to the most favorable business activities.

Big Data makes it possible to analyze the data at a more advanced level than traditional tools allowed. With this 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.

An interesting example of the use of Big Data technologies in the area of logistics is DHL, which implemented the so-called. "Resilience360" – 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. This 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.

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 behaviour.

5. Innovation in production logistics – Industry 4.0

The consequence of developing the Internet of Things and Big Data is the conception of Industry 4.0. The third industrial revolution, based on the computerization of business processes and information technology supporting manufacturing, has moved into a fourth wave, which has begun to be dominated by intelligent (smart) products, 3D printers or autonomous vehicles. The term "Industry 4.0" refers to the fourth industrial revolution. The first was related to the mechanization of production through steam engines, the second – with the introduction of mass production due to electricity, the third – with the use of IT and electronic controllers for further automation. The term Industry 4.0 was first used in 2011. It is expected that the realization of this vision may take 10-20 years. The "Fourth Revolution" will use digital product models, which will be formed to a large degree in compliance with the requirements of customers, and will be produced in Smart factories.

It is assumed that intelligent factories will largely have the ability to self-plan and self-adapt. The existence of a complete digital product model, together with the methods of its manufacture, model, intelligent factory with its real representation in networked Cyber Physical Systems are key conditions for the success of the "Fourth Revolution".

6. Conclusion

Nowadays, the vast majority of 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. The newest solutions such as Internet of Things, Big Data and Industry 4.0 create opportunities to meet the needs of customers and also contribute to the development of logistics and supply chains management.

Acknowledgements

Ministry of Science and Higher Education
Republic of Poland

7th International Conference on Engineering, Project, and Production Management (EPPM2016) was financed in the framework of the contract no. 712/P-DUN/2016 by the Ministry of Science and Higher Education from the funds earmarked for the public understanding of science initiatives.

7th International Conference on Engineering, Project, and Production Management (EPPM2016) finansowana w ramach umowy 712/P-DUN/2016 ze środków Ministra Nauki i Szkolnictwa Wyższego przeznaczonych na działalność upowszechniającą naukę.

ARiMR

7th International Conference on Engineering, Project, and Production Management (EPPM2016) was co-organised by the Agency for Restructuring and Modernisation of Agriculture (Poland).

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