APPLICATION OF MODERN INFORMATION TECHNOLOGY IN INNOVATION OF BUSINESS LOGISTICS PROCESSES

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Abstract: Business logistics in 21st century has been transforming its form, because it could be characterised by higher flexibility, innovations, accuracy, reliability, orientation on customer and application of worldwide logistic technologies and systems. Modern trends and logistic direction are mutually devoted just very little attention. The main aim of the paper is to identify the impact of selected information technologies on selected logistics processes. As a result of digitization, logistics forms the basis for the implementation of new modern technologies, the transition to advanced production systems and the differentiation of product offerings. This is also confirmed by the results of a survey conducted in 85 Slovak enterprises and a statistical evaluation of the survey.

Keywords: information technologies, logistic processes, business logistics, Warehouse Management System, Radio Frequency Identification, Pick-by-Systems

1 Introduction

In current turbulent times, logistics is impacted by globalisation and dynamic growth of new technologies. Every business reacts to these changes swiftly and flexibly and accommodates to needs of the market. Modern era brings also changes and new direction of logistics itself. If business wants to survive in competitive fight, it must include new means, methods, techniques, approaches and technologies of business logistics into its genesis. Nowadays, we can observe various approaches towards trends, depending on views of many authors and businesses.

Beginnings of warehouse evidence via computer reach back to 80th years, when they used to record volume of stored materials. Currently systems of warehouse management offer many options on how to manage, control, optimise stockroom and distribution operations. Processes which occur in warehouses are of large importance for the circulation of goods throughout the supply chain. Warehousing itself refers to taking care, transportation, loading, unloading, packing and processing of goods between the production and consumption for commodity and other various functions. According to authors Bartholdi and Hackman, the warehouse process of order picking takes 70% of time and 55% of costs which makes it a significant process in a warehouse. The order picking process can be one-dimensional, two-dimensional and three-dimensional (Bartholdi, 2014).

Warehouse is very important for every company, especially for production and retail sector, but also for the whole supply chain. Term warehouse is often mentioned in a negative context, as the cause of high costs and waste of time, without adding value to the product. Such understanding of warehouse and warehousing process is limited and does not observe the key tasks of warehouse management, such as: reducing the warehouse cost and holding inventory, increasing efficiency, increasing accuracy, increasing productivity while achieving greater value for customers and higher levels of service quality (Richards, 2017). To analyse and measure the effectiveness, according to Richards, it is necessary to approach the processes from where the deficiencies can be indicated. Basic warehouse processes are the following: receiving, put-away, internal replenishment, order picking, accumulating and sorting, packing, cross-docking, dispatch and shipping. Receipt and storage are considered inbound processes, while others are considered outbound processes. Beside these processes, there are also value-added services which are not obligatory but depend on the warehouse type and various provided services. In various warehouses, goods which usually enter as units of a larger scale, go through reorganization submitted to repackaging that results with units of a smaller scale. Afterwards, they are broken down into smaller quantities throughout order picking, packing and finally distribution. In this kind of warehouses, operations which are done daily are tied with human performance and greatly depend on it. The smaller the handling unit, the greater the handling cost. Smaller units require more labour and much more processing to be delivered. Precisely, pallet manipulation at a warehouse directly influences the time used for picking.

2 Literature Review

The core of WMS is in warehouse map, which includes detail parameters of storage space on shelves and free space while it follows the same rules and criterions e.g. in space utilisation and others. WMS also includes data of stored goods, their dimensions, stock rotation, packaging, dispatching. Every logistics operation is noted and hence it is known where logistics unit is located, what the parameters are and what its date of expiry is (Brezovský, 2014). Warehouse management involves the control and optimisation of the complex warehouse and distribution system. It might be said that warehousing and inventory management represent support to the production process and strive to complete coordination in relations with all functions, such as marketing, finance, human resources etc. Therefore, any disruption in coordination can cause serious problems throughout the whole business process.

According to Bartholdi and Hackman (2014), collecting orders in the warehouse wastes the largest share of time of all warehouse activities, approximately 70%. Therefore, it is very important to minimize the pickers' collection time and picking route. Affecting the mentioned total collection time by order decreases, and the number of successfully collected orders per hour increases. When collecting orders, it also appears that the largest share of work is done by warehouse workers. In order to meet large orders of many customers, the warehouses have several shifts performing tasks of collecting orders. From an economic point of view collecting orders makes up to 55% of operating costs in the warehouse. Therefore, it is important to reduce the order picking cost by optimizing time and picking route because it greatly reduces the overall storage costs.

Warehousing process includes receiving, putting away, storage, order-picking and dispatching of raw materials/products (Ming et al. 2013). Order-picking is one of the most important activities in the warehouse. This warehouse activity includes retrieving raw materials and/or products from the warehouse at the request of the customer, or presents a process of gathering raw materials or products which are prepared according to some customer orders (Reif et al. 2010). Order-picking, as labour-intensive warehousing operation, involves checking the availability of raw materials and/or products, assembling documents, defining the schedule for preparing orders and transportation. This operation could be very capital-intensive in situations when warehouse is automated (De Koster et al. 2007).

According to Rakesh and Adil (2015), the warehouse layout decision is important as it affects several aspects of a warehouse, including various costs and storage capacity. Step toward warehouse optimization is by use of their algorithm that determines lane depth, number of storage levels, lateral depth and longitudinal width of a three-dimensional order picking warehouse. It also helps in knowing the quantum of change in the cost due to change in different parameters, which are difficult to predict due to the interaction of multiple effects and trade-offs. When there is a need for achieving operational efficiency and cost savings, warehouse management and warehouse operations are appropriate areas, in terms of achieving savings

which will not jeopardize the quality of products and services. Author Lu conducted research for an algorithm for dynamic order-picking in warehouses, and according to it, the dynamic order-picking strategies that allow changes of pick-lists during a picked cycle are of importance (Lu et al. 2016).

Warehouse operations are critical for each supply chain. According to some authors, the efficiency and effectiveness of the supply chain network depends on warehousing operations and its performances (Rouwenhorst et al. 2000). Different methods of order-picking, equipment or information technology could be used for improving order-picking process. It is well known that implementation of Warehouse Management System (WMS) means integration in day-to-day planning and controlling processes. This software system presents a great support to warehousing process. Before WMS companies were using Inventory Control System. But WMS has greater results in terms of functionality and optimisation routines (Moellera, 2011).

We cannot forget about the difference between Warehouse Management System (WMS) and stock control. Under stock control we understand goods, their volumes, arrival at the warehouse, dispatching etc. Warehouse Management System manages works at the warehouse and hence differs from stock control. Warehouse management is carried out based on set of algorithms, which work with entrance data and set of rules, while system based on delivery not and orders receives determines where the items received will be stored, or from where it will be dispatched. Also it takes into account principles of FIFO (First In, First Out), LIFO (Last In, First Out), FEFO (First Expired First Out). Warehouse Management System generates expenses, manages movements of warehouse keepers in the warehouse, manages work of warehouse keepers and compares their performances with time data optimised for given operation.

Warehouse Management System works with storage positions, one-level and multi-level packaging which enables to monitor individual storage movements. In application of system management there are combined also other technologies assisting to decrease error rates and save time. There we include for example RFID, Pick by Voice, Pick by Light, conveyors and others. Radio Frequency Identification (RFID) has been identified as a crucial technology for the modern 21st century knowledge-based economy. Some businesses have realised benefits of RFID adoption through improvements in operational efficiency, additional cost savings, and opportunities for higher revenues. RFID research in warehousing operations has been less prominent than in other application domains (Ming et al. 2013). The sensor-based method uses a RFID tag (Jeon et al. 2010), a laser pointer, a wireless sensors (Shen et al. 2015) and a laser sensor (He et al. 2010; Lecking et al. 2006) for pallet detection and location. RFID is composed of a couple reader / tag. The reader sends a radio wave, the tag in turn sends an identification frame. Once the chip is powered, labels and tags communicate following the TTF protocol (Tag Talk First) or ITF (Interrogator Talk First). In TTF fashion, the tag transmits first information contained in the chip to the interrogator. The data / Event Handler consists of two parts, the Request Handler and the Data processing. The request Handler handles events (RFID reader or user request) and transfers the message to the Data processing unit that is responsible for processing. "The main tasks of this unit are: 1) determine the request type; 2) extract data in the envelope; 3) verify data formats and consistency and 4) record data in the shared database. After that, the notification service is automatically called to inform intended users."(Gnimpieba et al. 2015)

„Software systems are used to support the warehousing processes. Starting as Inventory Control Systems, todays WMS contain much more functionality and optimisation routines. Order picking as the process of retrieving products from storage in response to a specific customer request is considered as a core function within a WMS. " (Moellera, 2011) "Experiences from practice show that about a half of the total operating expenses of a warehouse is spent by order picking. " (Tompkins et al. 2013) or presents a process of gathering raw materials or products which are prepared according to some customer orders (Reif et al. 2010).

3 Methodology and data

The main aim of the paper is to identify the impact of selected information technologies on selected logistics processes. According to Commission Regulation EU no. 651/2014 distinguishes micro enterprises, small enterprises, medium-sized enterprises and large enterprises. The object of the research, which was conducted by questionnaire survey were small, medium-sized and large enterprises operating in the Slovak Republic.

Table 1: Definition of enterprises into micro, small, medium-sized and large enterprises

Enterprises	Staff headcount	Turnover	Balance sheet total
Micro enterprises	< 10	≤ € 2 million	≤ € 2 million
Small enterprises	< 50	≤ € 10 million	≤ € 10 million
Medium-sized enterprises	< 250	≤ € 50 million	≤ € 43 million
Large enterprises	> 250	> € 50 million	> € 43 million

Source: EUR-Lex. Commission Regulation (EU) No 651/2014. [online]. 2014. [viewed 2018-11-10]. Available from: <http://eur-lex.europa.eu/legal-content/SK/TXT/?uri=CELEX:32014R0651>

The survey was attended by 85 Slovak enterprises. Of the participating enterprises, 34.12% were from the automotive industry, 22.35% from the engineering industry, 16.47% from the electrotechnical industry, 10.59% from the food industry, 5.88% from the construction industry, 4.71% from the textile industry, 3.53% from the chemical industry and 2.35% from the wood processing industry.

In order to achieve the main objective of the paper, we have used several scientific methods. From the standard classical scientific methods we used: the method of literary research, the method of analysis and synthesis, the method of induction and deduction, the method of comparison, the method of scientific abstraction. From specific special methods, we applied a combination of inquiry methods, classification method, mathematical-statistical methods to quantify and quantify survey results. When asked respondents to determine the level of consent to claim, the Likert scale was used on a scale of 0 to 6 (where 0 - I disagree to 6 - I agree).

From the statistical tests, Pearson's Chi-square (χ^2) goodness of fit test was used. This test is included to tests of goodness-of-fit, which provide which allow to test null hypothesis H_0, on previously selected level of importance α that random selection was performed as division of given type, or unknown parameters against alternative hypothesis H_1, that does not come from this division (Ostertagová, 2012).

On the basis of the main objective of paper was determined and tested following hypothesis:

H_0: There is no statistically significant dependence on the significance level of α = 0,05 between the improvement of logistics processes and usage of Warehouse Management System (WMS).
H_1: There is a statistically significant dependence on the significance level of α = 0,05 between the improvement of logistics processes and usage of Warehouse Management System (WMS).

Calculated testing characteristics (Chi-square = 12.229) was compared with 95 percentile χ^2 – division with $(r - 1) \cdot (s - 1) = (3 - 1) \cdot (3 - 1) = 4$ degree of freedom $\chi^2_{0,95}$ (4) = 9,487729.

Based on the hypothesis testing, we conclude that there is a statistically significant dependence between the improvement of

logistics processes and usage of Warehouse Management System (WMS) on the significance level $\alpha = 0.05$, thus accepting the H_1 hypothesis and rejecting the H_0 hypothesis.

4 Results and discussion

Based on the survey carried out in enterprises in Slovakia, we found that enterprises would like to improve the information flow in selected logistics processes with the greatest percentage of 23.4%. Today, when environmental protection is still mentioned, predictions for the future tell us to think ecologically - "green". For this reason, it is essential that we manage the environment sensibly and prevent the negative effects that affect it to a great extent at the company level. In this respect, 19.6% of respondents identified recycling in the survey. Warehouse management would like to improve 17.2% of respondents and transport would like to improve 15.3% of enterprises. Among other logistic processes that Slovak enterprises want to improve, with a share of 13.1% material flow and handling with 11.4%. Table 2 summarizes the mean, median, mode, variance and standard deviation. Within the range of 0 to 6, enterprises most often identified value of 4 in warehouse management, transport and recycling. Mode with value of 5 has the information flow. The lowest values of mode have material flow and handling. Median with value of 4 have the information flow, warehouse management and recycling. The value of 3 has median in transport, handling and material flow. Table 2 shows that values are the most concentrated by information flow. The standard deviation has a value of 2.03. Values are the least concentrated by handling. The standard deviation has a value of 1.5. The maximum value of mean 3.63 has information flow from logistics processes. The minimum value of mean 2.15 has handling from logistic processes.

Table 2: Descriptive statistics of logistics processes

	Mean	Median	Mode	Variance	Standard deviation
Information flow	3,63	4	5	4,14	2,03
Warehouse management	3,02	4	4	2,9	1,7
Transport	2,39	3	4	3,37	1,84
Handling	2,15	3	2	2,24	1,5
Material flow	2,57	3	3	2,35	1,53
Recycling	2,95	4	4	3,55	1,88

Source: *own processing*

In the survey, we found that with the greatest percentage share of 41%, information systems affect procurement logistics. Production logistics is influenced by information systems with percentage share of 32%. Distribution logistics was reviewed by respondents to 27%. On the basis of table 3, we can see that procurement logistics under the influence of information systems have the maximum value of mean 4.07. The minimum value of mean 3.59 has distribution logistics. The most frequently of enterprises inclined to value 5 with middle value of importance in procurement logistics. Production logistics and distribution logistics have value of modus 4. Median of responses with value of 5 on a scale from 0 to 6 was achieved by procurement logistics and production logistics. Distribution logistics has median 4. Table 3 shows that values are the most concentrated by procurement logistics under the influence of information systems. The standard deviation has a value of 1.79. Values are the least concentrated by distribution logistics, standard deviation is 1.57.

Table 3: Descriptive statistics of business logistics entities under the influence of information systems

	Mean	Median	Mode	Variance	Standard deviation
Procurement logistics	4,07	5	5	3,21	1,79
Production logistics	4,05	5	4	2,59	1,61
Distribution logistics	3,59	4	4	2,47	1,57

Source: *own processing*

From the results of the survey, we would like to attention that in the area of selected modern information technologies applied in the logistics of Slovak enterprises, the greatest percentage 27% is Warehouse Management System. Radio Frequency Identification is used by 11% of respondents. The least enterprises usage Pick-by-Systems in logistics, with a percentage share of just 3%. Enterprises will be compel to accept new technologies under the influence of Industry 4.0, as well as Real Time Location System, Cloud Computing, the Internet of Things, as the upcoming digitalization enhances automation and connects industrial production to create a smart enterprise. In this way, the enterprise will be able to work as efficiently as possible and without human intervention or with minimal intervention. Based on table 4, respondents most often identified value of 6. This value is concerning Warehouse Management System. Pick-by-Systems has value of mode 0. Radio Frequency Identification has mode 1. Based on respondents´ answers is calculated mean, which maximum value is 3.47 in Warehouse Management System. The minimal value of mean 0.78 has Pick-by-Systems. Median of responses with a value of 4 have Warehouse Management System. The value of 1 has median at Radio Frequency Identification. Values are the most concentrated by Warehouse Management System, standard deviation has value 2.28. Values are the least concentrated by Pick-by-Systems, standard deviation has value of 1.59.

Table 4: Descriptive statistics of modern information technology in logistics

	Mean	Median	Mode	Variance	Standard deviation
WMS	3,47	4	6	5,18	2,28
Pick-by-Systems	0,78	0	0	2,52	1,59
RFID	1,79	1	1	4,32	2,08

Source: *own processing*

The survey suggests that the introduction of new technologies into the logistics of the enterprise is faced with barriers. Respondents are influenced by input costs at the greatest percentage of 37%. We justify the high percentage of this possibility that not every enterprise has sufficient funds to introduce new modern information technologies. Of course, it is important to draw attention to the fact that innovation in the shape of continuous improvement of logistics in the form of the introduction of new technologies is a significant source of competitive advantage in the market. Selected modern information technologies cannot be implemented in every enterprise because businesses vary in size, focus, financial and spatial capabilities. For this reason, 22% of respondents identified the possibility of implementation. Operating costs said 17% of surveyed enterprises. One of the barriers to introducing changes in the enterprise is always employees who are afraid about something new. This possibility is said 24% of respondents. In Table 5, we can see that the maximum value of mean 3.32 is at the input costs of modern technology. The minimum value of mean 2.15 has operating costs of modern technology. The most frequently of enterprises inclined to value 5 with middle value of importance in input costs. Mode with a value of 4 are operating costs, possibility of implementation of modern technologies in logistics and negative attitude of employees. Median with value of 5 have input costs and the possibility of implementation of modern technology. Table 5 shows that values are the most concentrated by input costs. The standard deviation has a value of 1.52. Values are the least concentrated by operating costs. The standard deviation has a value of 1.31.

Table 5: Descriptive statistics of barriers to the introduction of modern information technology in logistics

	Mean	Median	Mode	Variance	Standard deviation
Input costs	3,32	5	5	2,31	1,52
Operating costs	2,15	3	4	1,71	1,31
Possibility of implementation	3,28	5	4	2,21	1,49
Negative attitude of employees	2,57	4	4	1,88	1,37

Source: *own processing*

5 Conclusion

In the coming period will be a major challenge in logistics, technological changes under the influence of Industry 4.0 in the form of data analysis, Industrial Internet of Things and digitization. These include selected modern information technologies that have been analysed in the paper. Warehouse Management System, Pick-by-Systems, Radio Frequency Identification increase productivity, accuracy, and security in logistics of enterprise. The Fourth Industrial Revolution is causing a change in business models and increasing the share of new smart devices. Digitization and transferring big data will lead to better decisions, resulting in increased operational efficiency, cost reduction and risk reduction. Hundreds of thousands and even millions of devices communicate with each other and send data through different communication channels to information systems. The Fourth Industrial Revolution was built by the continuous expansion of the internet and it is estimated that by 2020, 50 billion to various objects connected to the internet (Evans, 2011). Processing big data and linking with digitization will have great potential for storage, transport and other logistics elements. This will have major consequences for enterprises because multiple delivery options are created for the customers and streamline warehouse operations. For this reason, enterprises will need to reflect on a change in business logistics and will have to adapt modern information technology to a greater extent.

The results of the survey show that enterprises in Slovakia would like to improve the information flow in selected logistics processes with the greatest percentage of 23.4%. We also found that information systems affect procurement logistics with the greatest share of 41%. In the area of selected modern technologies applied in logistics of Slovak enterprises it has the greatest percentage of 27% - Warehouse Management System, which digitizes stock records and picking goods. The survey suggests that the introduction of new technologies into the logistics of the enterprise is faced with barriers. Respondents are most influenced by input costs, with a percentage of 37%. As a result of digitization, logistics forms the basis for the implementation of new modern technologies, the transition to advanced production systems and the differentiation of product offerings. This is confirmed by the test hypothesis that says that on the significance level of $\alpha = 0,05$ there is statistically important dependence between the improvement of logistics processes and usage of Warehouse Management System (WMS).

Regardless of industrial sectors, we encourage enterprises to accept ongoing digitization. The exception is not the area of logistics, which plays a key role in the enterprise. The innovative environment will continue to be subject to the changes brought about by the phenomenon of digitization. Certainly fundamental, revolutionary and in-depth changes are waiting for us and each enterprise will have to accept and implement new, modern information technologies that will be related to the effective change of business under the influence of Industry 4.0.

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