MODERN FORMS OF SUPPORTING BUSINESS DECISIONS IN LOGISTICS

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Abstract

From the beginning of the twenty-first century the increase of big data popularity in the world is noticeable. The development of technology and its availability along with the amount of information allows for quite easy data analysis. Not only the time of decision making is of profound importance in logistics, but also the rightness of these decisions. Managers using aggregated data should be able to make analysis quickly, correctly and effectively. It can be done by dint of visualization forms. The article aims to demonstrate the factors that determine the choice of visualization and simulation forms by managers in enterprises. The impact of visualization and simulation methods on solving decision problems in logistics companies is intriguing. This article has been prepared on the basis of surveys and interviews with managers of such enterprises. The main drive to investigate the issue is the willingness to verify when, for whom, for what purpose and what forms of visualization and simulation are actually used in enterprises. During every day work, logistics managers have to face such problems as cost reduction, revenue increase, waste elimination, planning future activities as well as processes optimization. Such problems include, among others, minimizing empty kilometres, maximizing loading space on trucks, selecting locations for distribution centres, defining optimal delivery routes as well as

developing faster and cheaper solutions for transport, storage and complementation of goods. During the research project we tried to find out when enterprises decide to use such tools as tables, charts, maps and simulations in the problem solving processes. Last but not least, the above mentioned research study may constitute a drive for further development of visualization solutions as well as presenting the possibility of visualization and simulation, which indisputably enhance process optimization. Additionally, the article attempts to investigate which technical facilities and environment determine the need to use data visualization and simulation by logistics managers.

Key words: Visualisation, Logistics, Transport, Simulation, Management

1. INTRODUCTION

The logistic industry has been supported for many years by various supply chain process visualisation, modelling and simulation methods in order to optimise processes and consequently, to decrease the costs in the logistic industry.

According to Davidson and Kowalczyk (Davidson & Kowalczyk, 1997) "Logistics is the process of managing the flow and storage of materials and information across the entire organization with the aim to provide the best customer service in the shortest time at the lowest cost". The authors state that the most significant factors in logistics are: cost optimisation, flexible approach to the customer, speed and precision in fulfilling orders that might be obtained by a proper information flow. According to A. Pokahr and co-authors, logistics is highly complex as it comprises management, planning and coordination of fleet, orders, tracks and cargos (Pokahr et al, 2008).

Logistics is a very complex process in which problems get connected with each other and cumulate to form complicated models that need to be analysed and optimised. Therefore, in order to learn how to solve these problems one should classify them in the first place and subsequently assess the method of their mutual influence and general dependency (Pokahr et al, 2008). Moreover, one should ask a question whether the elimination of one problem will not cause the other one. In order to tackle the above problems one should utilise such modern tools as visualisation, modelling or simulation. This paper aims at discussing the logistic process visualisation and simulation. The hypothesis is that simulation is currently the most precise data visualisation and optimisation tool and supports the business activity management process and managers' decisiveness.

Managers are frequently obliged to make decisions that are often diversified. One should rise a question whether it is possible to categorise them. According to Hajdul managment decisions can be divided into the following three groups:

- operational
- tactical
- strategic

Each of the above group is characterized by the type of a manager, the level of decision making as well as the type of tools needed. Tools can be understood as different forms of visualization (Hajdul et al, 2014).

2. VISUALISATION AND SIMULATION AS TOOLS FOR LOGISTICS MANAGEMENT

2.1. Visualisation

Visual Management is a term simultaneously introduced with Lean Management. It relies on making signals by visualisations or signals of a current situation in the company. Visual Management supports problems diagnosing in the information flow as well as in the entire process. Due to visualisations, it is easier to recognise process stages and problems in the process. Furthermore, visualisation helps to recognise emergency situations and standard deviations. Visual Management boosts human stimuli, e.g. touch, flavour, hearing, taste and eyesight in particular. Such human brain stimulation has a positive impact on understanding operational processes in an easy way (Tezel et al., 2009).

What is also worth mentioning, Visual Management facilitates the process understanding, thus, it is easier acquaint new employees with company standards. In addition, visualisations might help the experienced staff members to better understand and abide by the company procedures.

What is more, data transparency is also influenced by visualisations depicting data. Visualisations eliminate the risk of keeping information secret from the managerial staff by employees. Furthermore, they help to eliminate information monopolies, which contributes to a better knowledge exchange between the managers and employees. In addition, visualisations have an impact on the present state assessment i.e. they enable managers to transparently assess how the employees perform their tasks (Tzortzopoulos, 2009).

The most widespread visualisation methods are charts that analyse historic or current data. The charts might be created by numerous programmes, hoewever among the most popular of them one may distinguish: MS Excel, Power BI, Tableu, QlikSense and others.

Taking into account Qlik Sense, it might be kept always updated which means that the visualisation presents not only historic information but also the current situation. This is a significant facilitation for the managers because they have an insight in their business or operational effects at once.

Below one may enumerate the examples of visualizations that constitutes support for the managerial level employees:

- maps with markers, heat scale, mini graphs,
- charts (for example histogram, bar chart, line chart, pie chart),
- modified charts (for example bubble cahrt, diagram, tree map, radar chart etc),
-dashboard - it is a representation of many visualizations on a one page, which gives a lot of transparency and a lot of information about the data,

- all of the above points are presented in real time, where the visualizations are constantly updated by using Big Data.

Different types of simple charts with historic data might help with noticing trends or critical moments. The historic data obtainment might cause that the company will learn a lesson for the future and, if combined with the management staff experience, it may contribute to cost reduction or process improvement.

The maps depict everything that might happen in the field. The charts or the scale of colours are very useful. The scale enables size-related and geographic analysis at the same time. Maps are an interesting visualisation form since they might be repeatedly created in such programmes as MS Excel or Fusion Google Tables. The current maps make it feasible to visualise e.g. unloading places, fleet deployment, the loading of cars and cost-intensive spheres. In addition, Buono also pays attention to a current large amount of data on maps (Buono, 2016). Besides, one might use basic filters in the newest editions of Google Fusion Tables and Power Map (MS Excel supplement). Due to the filters, a user makes autonomous decisions which data will be analysed. Unfortunately, the filters on the simple maps are not intuitive, which might interfere with the action speed and the tool intuitiveness in particular.

Visualizations may constitute a result of mathematical and estimation calculations, as they show the results and summary of the calculations. As an example one may point out is the work of Vikulov and co-authors, who minimized the risk by using mathematical formulas and subsequently presented the results in tables (Vikulov V. et al, 2014).

A much more extended visualisation form is visualisation in real time. It might be created by means of the business intelligence. The biggest advantage of the visualisations in real time is the fact that it is possible to start predictive analytics, which enables prognosis of the customer and market behaviour and premature detection of potential threats. The analytics relies on deducing and iterating various hypotheses that will lead to the generalisation of patterns implied by databases. This is intended to find potentially useful conclusions (Kotu & Deshpande, 2015). Predictive analysis and current state visualisations bring the managerial staff closer to the possibly optimum decisions (Elkan, 2013). The visualisations are necessary to explore data and might predict market behaviours in the future by using Big Data, statistical data and the process performance assessment (Kotu & Deshpande, 2015).

Last but not least, visualisations in real time show a current state of the investigated problem, which makes it possible for the managerial organs to immediately react to the detected dangers. Having launched new products or process improvements, the company management might additionally verify its assumptions and easilycheck their real influence on the company. This gives an opportunity to modify the assumptions and make partial changes in the processes in order to improve them for the sake of better operational or financial results.

According to Cichosz and co-authors: “Logistics managers should try to overcome barriers and proactively develop and implement logistics service innovations. The preliminary results of the research have already shown that integrating customers into the innovation process could increase their satisfaction and enhance the innovation." (Cichosz M. et al, 2017). This shows how important the use of innovative methods to achieve greater customer satisfaction is.

2.2. Simulation

Simulation is a method of investigating reality by means of techniques that enable recreation of real processes. It is a process of designing a real system model and conducting experiments in it in order to understand the model behaviour and learn the effects of applying various strategies (Ingalls, 2001). According to another definition, simulation is determined to be a confined model (Walker et al. 2011) that reflects real situations or processes (Lamb et al. 2018) and is susceptible to manipulations. The model enables investigation of relations between influencing variables and their users' interaction (Kunkler, 2006).

The computer simulation might be responsive to numerous problems, for instance, how the management process course should look like, how to plan parcels, how to modify the process to make it more efficient (Graudina & Grundspenkis, 2005).

Based on the adopted data and assumptions, simulation enables presentation of the results of possible process solutions. Due to simulation one might check whether the solutions are optimal or something in the process needs to be corrected. This is the main reason why simulation is useful for the management staff who can make sure that their analyses with their results are correct and the proposed solutions are optimal. In the S. Mitchell's view (Mitchell, 2009) computer simulations are alternative to the analytic solutions to mathematical models. Moreover, they are characterised by a significantly higher flexibility than mathematical models, for instance due to a smaller number of required solutions and limits, with the same result usefulness. In A. Greaseley's view (Greasley, 2004) the main simulation application areas are: production accompanied by logistics and transport and all investment decisions, queuing systems and broadly defined customer service. S. Robinson. (Robinson, 2004) goes one step further and finds the simulation support to be practically possible in each queuing system, i.e. a system with elements that go through all processing stages. As a consequence, the state of the elements or the entire system is alatered.

Simulations are often related to process modelling. Simulation experiments are conducted in the case of modelled processes. This is particularly significant in the logistics management area that is considered to be a processual activity due to its features. J. Reiss distinguishes two interpretations of the word "simulation" (Reiss, 2011):

- using IT tools to solve equations that cannot be solved with analytic methods,
- imitating a given process in another (usually computer) process.

Moreover, the author points out that simulations are characterised by advantages compared to traditional experiments. These advantages include (Reiss, 2011):

- the possibility to repeat the experiment in the precise way,
- the possibility to change the system parameters that might be difficult or impossible to change in reality,
- decrease in the experiment costs,
- shortening the experiment performance period.

The significance of using simulation methods in the business decision- making process in the logistics area is presently increasing due to a more and more frequent application of the IoT (Internet of Things) technology and the establishment of Cyber-

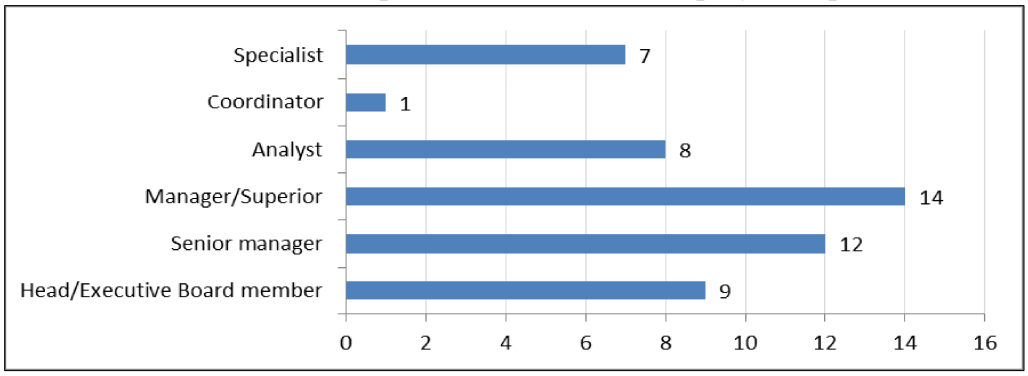
Physical Systems (CPS). Thus, it is necessary not only to perform simulations in the "offline" environment that tends to reflect the system state in its functioning or postulated conditions, but also to perform "on-line" simulations simultaneously with the CPS functioning (Cedeño, et al., 2018)
What is inseparably linked with the simulation research performance, is the necessity to validate the models. The validation is a process of specifying a degree to which a model is an accurate reality reflection in terms of the intended model applications.

3. RESEARCH OF VISUALISATIONS AND SIMULATION AS TOOLS SUPPORTING THE DECISION-MAKING PROCESSES OF LOGISTIC OPERATORS IN POLAND

The objective of this research is to find out whether the logistic operators in Poland use visualization and simulations techniques and tools while making operational or business decisions? If so, is the process simulation used in each employment position? For that purpose the survey has been conducted among the logistic operators' employees. The research was conducted in April 2018 and was performed online, however the survey was sent to the companies that operate in Poland. It is a pilot study and an introduction to detailed research on using Big Data and visualisations in production companies and logistic operators. In the detailed research, one will recognise a statistical sample size in order to obtain results that will enable verification of research hypotheses.

Fifty one (51) respondents participated in the survey. 67.6% of them work at least in one of a managerial position depicted in Chart 1. Over 80% participants of the investigated group are involved in transport and about 47 % in warehousing. Over 90% of the investigated group work in a company with at least 251 employees and 27.5% in an enetrprise with more than thousand employees. Most answers come from the employees of the logistic operators that provide their services in Europe. 35% of responses come from the companies that run their activities only in Poland and only 11.8% of the companies function worldwide. Half of the companies possess only foreign capital and 27.5% of them possess only domestic one. The remaining companies possess mixed capital. Chart 1 depicts the distribution of the respondents in terms of their positions held in the logistic operators.

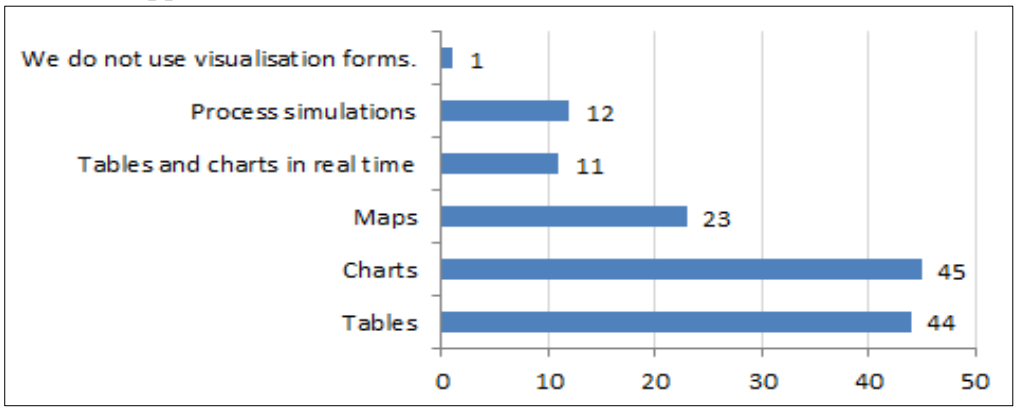
Chart 1. The structure of respondents in terms of employment positions



Source: own

Chart 2 presents data about the use of various visualisation methods by the logistic operators. This is intended to investigate the most popular data visualisation methods among the respondents.

Chart 2. Application of various visualisation methods



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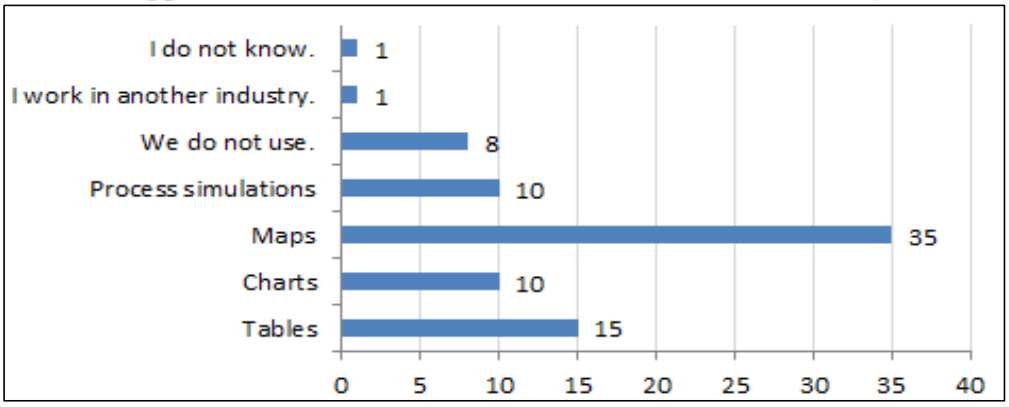
Based on the data indicated in Chart 2, the majority of the investigated companies mainly uses tables and charts as well as maps in the next place. However, it is interesting that a similar number of the surveyed staff members mentioned that they used any kind of the data visualisation form. Almost 85% of the respondents claim that they highlight data with various colours, a scale of warmth, etc.

Chart 3 illustrates the data about visualisation forms for optimum localisation of the central warehouse or distribution centre.

Chart 3. Application of visualisation forms to calculate the Gravity Point



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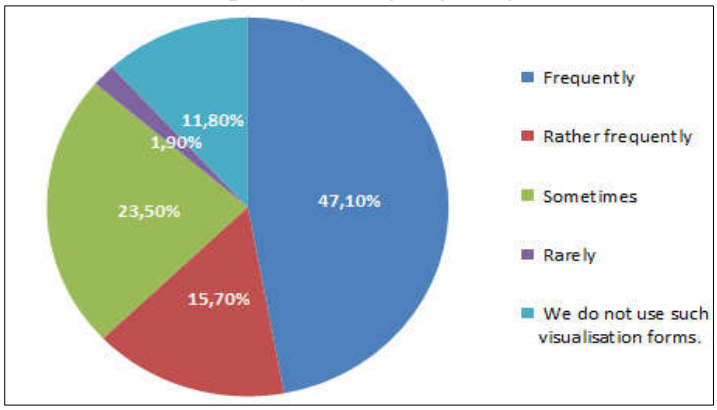
Data visualisation on the map is applied to calculate the Gravity Point of a warehouse or a distribution centre in the largest scale. An interesting analysis form is to simulate various deployment places and their comparison for minimising redistribution distance. Only 16% of the respondents makes absolutely no use of visualisations in the indicated analyses and could result from the fact that decision making is preferably based on numbers and managers' intuition and opinions. Barely 20% of the respondents indicated the solution which is to simulate and look for the

optimum location of the distribution centre or warehouse. It is probably more time-consuming to obtain appropriate data and implement them to the simulation model than to use maps.

Chart 4, shows frequency of using varied coloured graphs to present the analysis results.

Chart 4. The frequency of highlighting data with colours

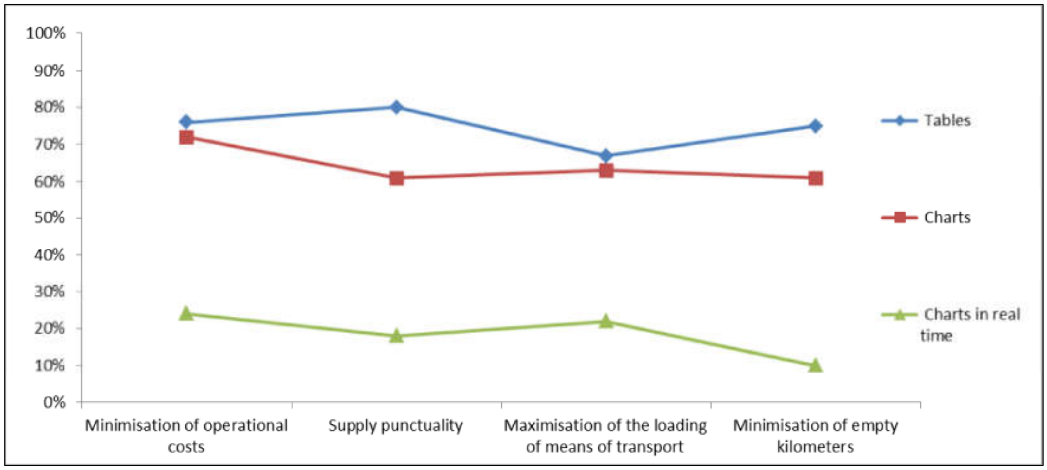


Source: own

Based on the information included in Chart 4, it is possible to state that important data in the companies are frequently highlighted with various colours in order to show the crucial data. It appears to be natural because colour scales are basic tools in the data analysis as they easily boost human stimuli. In addition, the colour scale activates the right brain hemisphere. As a consequence, the results from the managerial staff members' analyses are much more creative.

In Chart 5 describes the use of, there are answers to questions about using various visualisation forms for the sake of optimising transport processes. An interesting research result is the fact that such data presentation form as tables and charts prevailed in the case of questions about the kind of visualisations related to these operational problems.

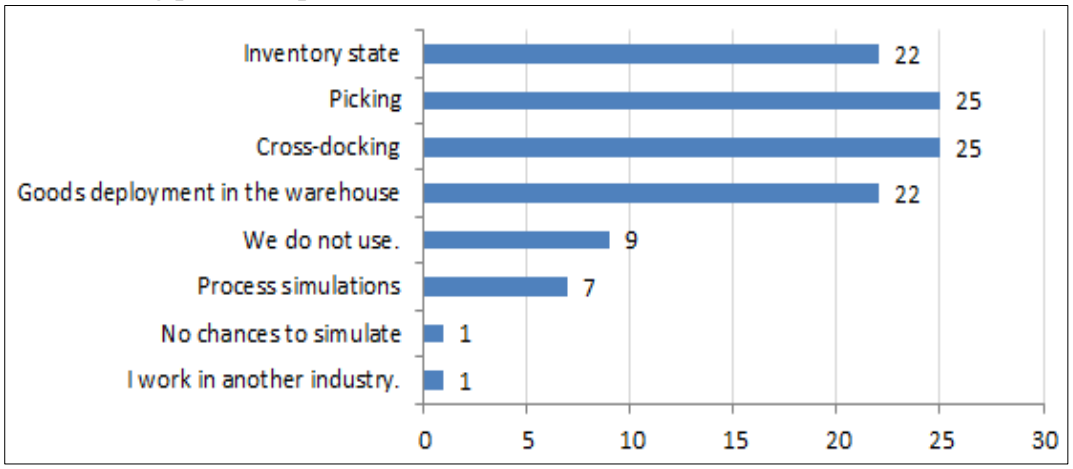
Chart 5. The results of the survey about the visualisation forms applied to transport process optimisation tasks



Source: own

Moreover, according to Chart 5 the least effective visualisation forms are used in Polish companies. Nonetheless, it is worth noticing that there are more and more frequent charts in real time. This might be driven by the continuous Big Data development in Poland and worldwide. As regards to transport-related questions, it is worth paying attention to the occurrence of maps next to the questions related to supporting track planning by visualisations. This shows that the data presentation on maps is more and more popular in such programmes as Elcar. Chart 6 presents the data visualisation used in optimising warehousing processes.

Chart 6. The results of the survey related to the visualisation forms applied to warehousing process optimisation tasks



Source: own

According to chart 6 companies use a visualisation to optimisation warehousing process especially to picking and cross-docking. These processes in many warehouses decide about warehouse processes efficiency. The key role in that processes plays time. It could be concluded that visualisation is a good method to optimise time driven processes.

The simulation-related answers most frequently start appearing while the data from the warehouse is visualised. 40% of the surveyed companies already use simulation while optimising warehousing-related processes. The number of simulation records in this case is more than twice higher in the case of transport processes. The respondents use simulation while investigating the processes related to goods picking, cross-docking, goods deployment in the warehouse and checking the inventory state.

One may state that the research results present the advancement grade of visualisations revealed by the surveyed. According to the abovementioned, visualisation tools might be developed and used even faster. Why should also be investigated is whether the companies start using the software like business intelligence or reach for simulation-related tools.

4. CONCLUSION

Visualisation and simulation have been confirmed to be the essential tool for the managerial staff. It is widely accepted that simulations are theoretically the most reliable visualisation tool during the process optimisation. However, attention should be paid to the fact that, for the time being, companies tend to use less complicated visualisation forms. This might be driven by numerous factors that should be investigated in the future. The reason for lesser usage of simulation model is the lack of educated human capital, prices of software solutions and reliable data. Cost-benefit analysis might reach a conclusion that the cost, which is potentially imposed on simulations, is worthless compared to the advantages gained from such a solution. Nevertheless, results depict that the companies in Poland used various visualisation forms while making business and operational decisions.

Tables and charts are the most frequently utilized visualisation techniques and tools for the investigated group. Data directly related to a network of roads or terrain are visualised by means of maps. Charting and simulation on real time data is still rare. In the future research it should be investigated whether there will be an increase in the significance of charts in real time and simulations in the upcoming years. The simulations require much more advanced tools than basic Excel spreadsheets. In addition, such tools are much more complicated, therefore a smaller group of educated people can use them effectively. It is to expect that due to technological progress, much more complex data (especially those that come under the term Big Data) and necessity of fast decision making, usage of sophisticated visualization and simulation will come in progress.

Industry 4.0 and Logistics 4.0, which indisputably is less complex issue, have altered the approach to business. It is Logistics 4.0 that indicates the process automatization and digitalisation development direction. The increase in the data significance is inevitable owing to the fact that logistic operators intensify their actions aimed at improving the flexibility of their offer to customers, the quality and punctuality of their services and making an attempt to reflect logistic processes. In pursuance of meeting Logistics 4.0 logistic operators need an increasing amount of data that might become larger and be useful. This means the data ought to be easily utilised to perform analyses. The above needs might be responded by Big Data that is contemporarily getting more and more widespread in numerous institutions and companies. (Szymańska O., Adamczak M., Cyplik P., 2017) What is worth emphasising, visualisations are helpful in performing such analyses since colours, charts and maps are much more readable that large data bases. Furthermore, visualisations might provide a broader area of observations and combine numerous facts with each other. As amounts of data keep coming, it is necessary to use Big Data consciously in order to improve processes in the company (DHL). The Big Data appearance should encourage management staff to search for answers to significant questions and start making decisions based on facts not on speculations (McAfee A., Brynjolfsson E., 2013). For the above reasons, in the future, the correlation between company development and the use of Big Data should be examined. Las but not least, the impact of Big Data on the development of visualization and changing the style of business management may also constitute an interesting field to be investigated.

In addition, visualizations and simulations can be used in research on the performance of various models of processes occurring in logistics. An example of the use of visualizations for the analysis of processes is Nowicki's work and co-authors, who studied models of the process of document exchange in logistics companies (Nowicki T. et al, 2017). The issue of using visualization and simulation to obtain process optimization is also an interesting issue that can be addressed in the future.

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