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The Influence of New Information Technologies in Supply Chains Logistics on Mobility in Urban Areas

Abstract: Cities are places of countless logistics processes, i.e. the processes of flow of all kinds of resources: human, material, information. The basic problem of contemporary cities are factors limiting their sustainable development. Most of them originate from excessive congestion caused by individual motorization and road freight transport. In recent years, supply chains intensively develop and implement new information technologies. That aims at rationalizing the business logistics processes by improving the information flows which is followed by reducing the demand for physical resources and the reduction of processing time and costs. Because the cities are large areas of logistics processes related to the economic activities of enterprises, the purpose of this article is to answer the following question: how do new information technologies, used in logistics processes, influence the structure of resources mobility in urban areas and how they can help in solving problems of congestion in urban areas. The main assumption of the study is that information flows can partially substitute real flows, which leads to the main thesis of the research that new technologies which streamline the flows of information in B2B and B2C relation can reduce the demand for goods and human flows within the cities. That rationalization translates into changes of resources demand structure and thus a change in demand for their mobility. The study used analysis and deduction method based on the literature and real life examples in the field of information technology which are already in use and those that can be used soon in logistics processes. This field of research is underdeveloped because logisticians focus their research on economization of business logistics processes and do not pay much attention to how they can influence urban areas.

Keywords: industry 4.0; innovations; logistics; mobility; new information technologies

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Introduction

Currently, more than 70% of Europe citizens live in urban areas. The UN projects that by 2050 this percentage will reach 80%. That means the development of urban areas will have a major impact on future sustainable development (economic, environmental, and social) of the European Union and its citizens (*Urban Agenda for the EU*, 2016). The growing population of the cities leads to growing problems. They mainly relate to poverty and social disproportion of noise, pollution, congestion, accidents, use of non-renewable fossil fuel, loss of greenfield sites and open spaces. That is why the priority of the EU 2020 stated in the Urban Agenda for the EU (2016) is the strategy for a smart, sustainable and inclusive growth of the cities.

Most of the problems occurring in urban areas come down to road transport infrastructure and increasing car-based communication and transportation (*Special issue – City Logistics*). It is not easy to find a solution as cities are spaces for physical flows. All the activities within the urban areas relate to the processes of satisfying needs. The starting point of every process is the city-user's need and the end of the process is the level of user's satisfaction. Human activities within urban spaces are mostly connected with the need of mobility. Szołtysek (2011: 20) uses the definition of mobility needs which are the result of a lack of spatial compatibility between the components necessary for any human activity (definition of Piskozub, 1979: 247). The observations and interviews[1] show that the most important characteristic of mobility for the users is time and effort connected with journey, very often more important than the costs of the process (*Gdańskie Badania Ruchu*, 2016). Only car-mobility can support the transportation need in the most direct and convince way. The more complex the journey is, the more competitive a car is as a means of transport. This is one of the main reasons why individual mobility is still so popular within the cities (Szołtysek, 2011: 98–99). This is what makes urban spaces so busy, noisy, polluted, and dangerous. The main question nowadays is how to manage and reduce these phenomena. The present article is a response to such a problem. Its purpose is to answer the following wuestion: how do IT innovations, used in the logistics processes, influence the structure of resources mobility in urban areas and how they can help in solving problems of congestion in urban areas.

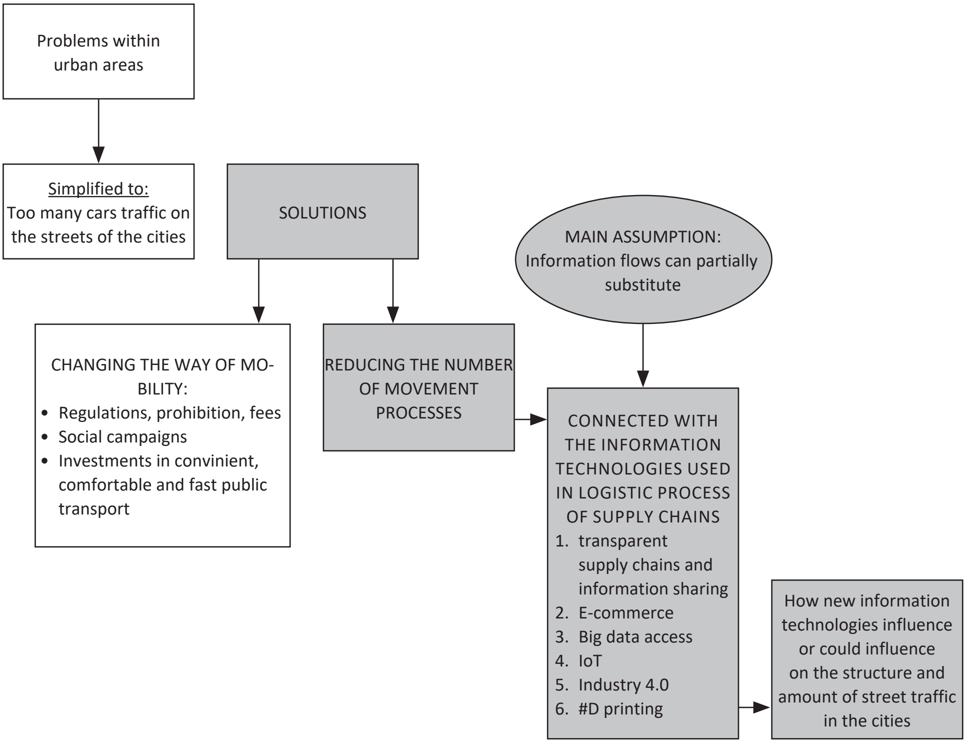
Methodology

The study used analysis and deduction method based on the literature, expert interviews and real life examples. Fig. 1 shows the deduction process.

For this research, the problems of the cities were simplified to the problem of "too much traffic of individual and freight automotive problem". In that case two paths of solutions were identified: 1) solutions leading to changing the way of mobility,

[1] In Summer 2016 the author interviewed Prof. J. Supernak from the Department of Civil, Environmental Engineering in San Diego State University, San Diego, California. Prof. Supernak's research interests are in the general area of Transportation Engineering, such as: travel demand analysis, intelligent transportation systems, transportation economics, and transportation safety. In Autumn 2016 the author interviewed Prof. M. Browne from the Department of Business Administration in the University of Gothenburg, Gothenburg, Sweden. Prof. Browne's main research focus is urban goods transport and all aspects of sustainable logistics including: e-commerce and home delivery, energy use in the supply chain and the interaction of policy and business decisions, the importance of working with stakeholders in the cities.

Fig. 1. Analysis and deduction process of the research (the author's own work)



maintaining the same amount of needed movement processes and 2) solutions leading to reducing the number of movement processes. Of course, those paths are not contradictory and should be used together, however, in this research I focused on the search for solutions in reducing the number of needed movement processes.

One of the most powerful tools of local governments are regulations, prohibitions, and fees. However, regulations reduce the elasticity and very often cause objection to the ideas. This directly affects the perceived quality of living. We can achieve better results if people are convinced to satisfy their mobility needs in different way than by their own car (for an example see: *Z fotela w samochodzie na rowerowe siodełko…, 2016*). Local governments and a number of NGOs try to change the way of thinking about mobility by organising social campaigns. But that is not enough. Even if people agree with the idea, in the final calculation they choose solutions that are faster and organizationally easier. A good example is Gdansk, where in spite of numerous efforts to convince inhabitants to cycling and using public transport, the amount of individual cars on the streets constantly increases (*Gdańskie Badania Ruchu*, 2016). A similar tendency is shown, for example, in the results of an extensive CAWI survey (Fiorello, Martino, Zani, Christidis, Navajas-Cawood, 2016). The problem is probably because the public transport is still not competitive enough in comparison with one's own car. There is still a lot to be done in the field of making public transportation, walking and cycling more attractive. However, this article is focused on the second group of solutions.

When it is not so easy to change the way of mobility it is worth to think about the tools reducing the number of mobility processes. This research was based on the main assumption that information flows can partially substitute real flows. Because of the cities are large areas of logistics processes related to the economic activities of enterprises. The present research considers solution that are can be implemented from the information technologies used nowadays in the supply chains or which are going to be implemented in the near future. According the Zioło's (2012) thesis, innovation is an essential factor which widely affects changes in people's behavior, businesses, institutions, methods management, social attitudes, and cultural impact. Therefore, it can be assumed that IT innovations used in logistics processes also have an impact on the mobility behavior of citizens and enterprises, their structure and size within the urban areas. The study proves that new technologies which streamline the flows of information in B2B and B2C relation, can reduce the demand for goods and human flows. Such rationalization translates into changes of resources demand structure and thus a change in demand for their mobility.

The main tasks of current and future supply chains logistics

At the core of every human activity is the accessibility of every kind of resources: information, staff, materials and goods. The most important is that the necessary resources should be physically accessible in the right place and time, in sufficient quantity and at the right price. The implementation of these proposals corresponds to logistics (Chaberek, Karwacka, 2012: 85). Logistics is a process aimed at handling every rational human activity by supplying needed resources in an effective, efficient and beneficial way (Chaberek, 2011). In other words, the essence of logistics is to control all resources flows through the integration of these flows in time and space (Chaberek, 2002: 36). The control, of course, is done by using the information flows. In economic practice of enterprises, the implementation of logistics goals is happening through the management strategies that use all the latest innovations in the field of acquiring, processing and transmitting information, that is through the implementation of all IT innovations (Chaberek-Karwacka, 2012). Logistics, nowadays, plays the key role in the processes of satisfying human needs. Taking into consideration that most of consumers live within urban areas, the logistics solutions of the supply chains are particularly focused on "the last mile" logistics problem. Twelve global challenges which will have the greatest impact on the industry in the upcoming 10 years, were identified. Those 10 root trends address changes in society, shopping behavior, environment and technology. "1) Increasing urbanization and the rise of megacities will impact the size of stores, logistics and the supply chain, and distribution infrastructures, among other factors. 2) Aging population will have economic and political consequences related to the amount of money spent on necessities like food and drink, and the type of delivery services, store formats and locations offered to older consumers. 3) Increasing spread of wealth will lead to a growing middle class in developing regions, impacting consumption and availability of food items and providing a source of growth for manufacturers and retailers. 4) Increased impact of consumer technology adoption will be reflected not only in consumers' own behavior but also in their ability to influence the buying behavior of other consumers as the use of social and digital media continues to spread. 5) Increase in consumer service demands will define new service models, offered via the Internet, that move beyond selling individual products and will bring different types of "solutions" to consumers and shoppers. 6) Increased importance of health and wellbeing will have significant ramifications as sales of healthful products and services are expected to nearly quadruple in the coming five years. 7) Growing consumer concern about sustainability will lead consumers to look to governments and companies to play a major role in combating climate change. 8) Shifting of economic power to countries like China and India will cause trade areas to evolve and a new generation of globally competitive companies from these developing markets to emerge. 9) Scarcity of natural resources like energy, water and food will become a growing issue as demand is projected to outstrip easily available supplies over the next decade, resulting in increasing production costs. 10) Increase in regulatory pressure will be seen particularly for hot-button areas like the environment, sustainability and food safety. 11) Rapid adoption of supply chain technology capabilities will enable a more synchronized value chain with greater visibility and traceability. 12) Impact of next-generation information technologies like cloud computing will lead to a new way to deal, jointly, with business and technology in the consumer goods industry" (*Future Supply Chain 2020*, 2012).

Taking into consideration those trends and challenges the conclusion is that the most important in logistics nowadays will be total information sharing among all players on the market. All those political and social changes are accompanied by the rapid development of information technology that allows operators to adapt to them. The organizers of supply chains rapidly adopt technologies that enable integration of partners, more transparency, sharing information and changing the models of cooperation. Universalism of Internet services enables electronic flow of information, thus getting a lower cost for solutions based on it and makes that access to technology virtually unlimited (Kawa, 2011).

New technologies enabling the reduction of physical flows

Changes in mobility behaviors in the urban areas relate mainly to the Internet era. According to Molenaar (2013: 3–4) the Internet era really began in 2008. Prior to that there was Internet, but it did not form an integral part of people's behavior. Starting with the 2008, the use of tablet computers, iPads and smartphones has been rapidly popularized. Cloud computing is already possible and will facilitate this change even further. Internet forms are nowadays an important part of buying process. Previously, people had to go to shops to buy; now they can go to shops, but they can also visit webshops, or both, as part of a buying process. Moreover, these days the Internet is an integral part of people's lives and satisfies not only buying needs (Molenaar, 2013: 4).

Digitalization of process, information, activities and even products leads to changes in supply and buying behavior. Linking computers, systems and tills by EDI made it possible to align business processes. This enabled the inventory function to be outsourced to an external party or the supplier. Advantages for the retailer are of course efficient stock management and reduced costs. A further development was the possibility of holding stock at an alternative location. One manifestation of this development is the formation of "city-hubs", providing local storage for all retailers in the city. With just limited stock held at the shop and an Internet connection, products are quickly dispatched to the customer's home. Due to the minimal amount of stock shelved in the shop and smaller square footage, first overheads are reduced but also the amount of unnecessary freight capacity and thereby reduced amount of physical movements (Molenaar, 2015: 27).

However, Internet buying does not replace the number of final products needed to be moved to the customer. It changes the structure of those needs, replacing individual private mobility by freight home delivery. One of the most obvious solution which seems to be able to replace the needs of physical movement is 3D printing technology (3DP). There are some visionaries who see the 3D printing technology as an end of global supplies chains like we see them today.

Recent technological innovation allowing virtually transmitted digital bits of information to be made into real-world atoms is likely to be significant. These are just two futures involving a radical recent innovation representing a conjunction of digital information, automation, materials science and computer-aided design: 3D printing or 'layer-by-layer' additive manufacturing (Britchnell, Urry, Cook, Curry, 2013). According to Ye (2015), this technology allows an automated production in which a product is build up layer by layer using a computer aided design (e.g. CAD drawing) from a range of materials which are available in the form of liquid resin, filament and fine powder. As a result, a range of different metals, plastics and composite materials can be used to make 3D printable objects. 3D printing is a rapidly evolving technology consisting of many different methods for the fabrication of a new generation of advanced components and structures. The most important aspect of this technology is that due to its additive nature it is a sustainable, scalable and viable future manufacturing method (Thomas D.J., 2015).

3DP has experienced significant advances and today the technology is being used by a variety of industries. The three largest industries contributing to the 3DP market are consumer products/electronics, automotive, and medical. 3DP offers these industries several benefits over conventional production, such as shorter development times, lighter components, easy customization, and more design freedom. Despite various barriers that need to be dealt with for 3DP sector to reach higher market penetration, such as limited robustness of processes, material limitations or high component costs, etc. there is a growing international interest in using 3DP technology. For example, Australia's plan for 3DP to move down the supply chain in its mining and metals sectors, and South Africa's support for the development of a high-speed 3D printer for titanium parts. The entire 3DP industry has experienced an impressive growth of 27% on average for the past 26 years. The global market for 3DP products and services grew to $3,07 billion in 2013. Estimates are already being made that the global 3D printing market will reach approximately US$3 billion by 2018 according to the executive summary of the report "3D Printing – A Global Strategic Business Report" by Global Industry Analysts. Personal manufacturing technologies will profoundly impact the design, making, transportation, and consumption of physical products (Britchnell, Urry, Cook, Curry A., 2013). It is believed that the sector will continue with its growth for the next decade (Ye, 2015).

In the workshop taken by Britchnell, Urry, Cook and Curry (2013) there were developed four scenarios for 2030 on two axes: first, the extent of corporatization of manufacturing, design and distribution systems; and second, the overall degree of individual engagement with 3D printing. Tab. 1 shows only two of the probable scenarios which can influence on the number or structure of urban travel needs.

Printing processes will continue to improve, with some advancing quicker than others. Stronger builds, smoother finishes, and multiple material depositions are made possible. Machine manufacturers will focus on increasing the speed of the processes. 3DP shows the most potential for increasing a company's time and flexibility capability. 3DP allows a better time capability as it provides faster development speed for innovative products and faster delivery speed for customized products. It provides more flexibility through easy customization, thus allowing more variety, and is more flexible in terms of inventory management, as it allows on-demand production for products with demand uncertainty. Research show that 3DP stimulates the decentralization of manufacturing. Decentralized manufacturing setup will replace the long-distance transport on the demand side, with material transport of the raw material on the supply side (Ye, 2015).

Tab. 1. Two Possible Scenarios of the 3D Printing Technology Development till 2030

No.	Name of the scenario	Influence of the 3D printing technology on the movement needs within the cities
1.	Desktop factories at home	Demand for travel by consumers for shopping curtailed by desktop printing especially in the mass-manufactured, cheap and disposable products sector. Infrastructure for the movement of finished products replaced by a competing market of feedstock suppliers.
2.	Localized Manufacturing	Due to aesthetic and economic concerns costumers have limited 3D printing at home. However, 3D services are afforded by digital materialization in new industry of local print shops and online retailing. Consumers' travel needs relate to access to these print shops to print the personalized 3D designs they have purchased from the databases of suppliers such as Google and Amazon.

Created by the author based on the workshop scenarios developed by Britchnell, Urry, Cook, Curry (2013)

There is no denying that changes will occur, what is difficult to predict however, is the scale of the disruption, the forms it will take, and the timeline for the full impact to be felt. Most executives and managers still know a little about the technology but are not aware that it represents a disruptive game changer to their business models. Some of the more immediate effects could be a reduction in air cargo's market share for rapid transport of prototypes, aerospace and automotive sub-assemblies, spare parts, mold tools, electronics assemblies and consumer products, and other high-value, time-critical goods. UPS and DHL, for instance, are already taking their first exploratory strides with this technology and have installed 3D printers in their respective research centers to see how they may be integrated into their operations (Moore, 2016).

However, when it comes to the influence of the 3D printing technology on mobility needs, we can only speculate about the future. There are other phenomena which already change the structure of urban-travel needs. The reduction in general movement needs is achieved through better use of information flows, especially by information management in the Industry 4.0 solutions. The concept of "Industrial Revolution 4.0" (Industry 4.0) assumes the precise fit of global flows of material and information in the criterion of time, quantity, place, etc. (Bujak, 2016). The concept of Industry 4.0 describes the increasing digitization of the entire value chain and the resulting interconnection of people, objects and systems through real time data exchange (Hecklau, Galeitzkea, Flachsa, Kohlb, 2016) The term "Industry 4.0" was first used by The German Federal Government as a high-tech strategy to make Germany the innovation leader with a strong economy. The fourth industrial revolution comprises the merging of IT networks with mechanised, electrified and automated production plants, materials and logistic systems to create production systems that control and optimize themselves. The focus in that topic lies on the following research: control of complex systems, safety, organization and design of work, and resource efficiency (Marré, Beihofer, Haggenmüller, 2015). The enormous amount of information gathered and generated by Information and Communication Technology (ICT) systems and sensors installed at the shop-floor needs to be presented in a manner that could truly speed up production processes, enable immediate reaction to issues and shortcomings (Sipsas, Alexopoulos, Xanthakis, Chryssolouris, 2016). A typical example of Industry 4.0 is a Cyber-Physical System, such as smart vehicle. The raw data includes driver's operation, the condition of vehicles, driving route and destination, i.e. data collated by various types of sensors during the vehicle operations. The data is then uploaded into a local database which comprises of a private data center with an outside database. The outside database is used for the information collected from the outside of the vehicle, such as web society and life logs. This data is uploaded by drivers when they are stationary. In the data center, the data is not only stored in the database but also analysed and converted into valuable information, which includes two types of data – public and private. This valuable information can address many useful notations for the drivers, such as route prediction and driving skills analysis. With this production, a data mining method is used for the route prediction which achieves 80% prediction accuracy (Qina, Liua, Grosvenora, 2016)

As it was already mentioned, the paradigm of new industry solutions promotes the connection of physical smart object, both to each other and to the Internet (Sipsas, Alexopoulos, Xanthakis, Chryssolouris, 2016). A smart object can be a sensor, a thing, or any physical device that has the capability to sense the environment, to collect the data from it and to interact and communicate it with any other physical device. These devices are called smart since they show intelligent behavior in connection and interaction with other devices via a wireless protocol and operate interactively and autonomously over the Internet. Examples of these devices are smart watches, building automation sensors, medical and healthcare devices, smartphones, smart TVs, vehicles, security system, etc. From integrating these devices for interaction and intercommunication over the Internet emerges the field named Internet of Things (IoT). Various constituents ranging from link establishing to efficient data communication pose a series of challenges in this context (Ahmad, Rathore, Paul, Rho, 2016: 1102). The purpose of the new IT solutions is to improve combination of multiple processes or objects, from production to sales, to make everyday life easier. IoT refers to a system that allows the automatic transfer of data in complex networks of connected devices. The collection, processing and transfer of data between, among others, buildings, cars, medical centers, objects, devices, and companies in the supply chain is transferred to the virtual world (Szozda, Świerczek, 2016). An example can be a parking space occupancy solution in a city street supported by parking slot sensors and delivered via Smart City company's applications. A user as a service beneficiary could be in the proximity of IoT devices that generate such data (Mihailovic, 2016)

The realization of the Internet of Things (IoT) is possible due to recent progresses in Information and Communication Technology (ICT) sector and it paves the way for innovation in every area of science, technology and human life in general. Interconnecting people and things anytime, at any place, with anything and anyone, ideally using any path/network and any service implies radical transformations of human activities, as well as significant changes in businesses and society. Regardless of which estimates will be proven correct, it may be expected that the major objectives for IoT (the creation of smart environments and self-aware things for climate, food, energy, mobility, digital society and health applications) will be achieved in the years to come. In other words, the growth in the total number of IoT devices is projected to provide substantial economic and social benefits in the way of cost savings, value creation, productivity improvements, and general economic growth (Maksimovic, Gavrilovic, 2016). That way, the IoT solutions are going to create new patterns of human's mobility behaviors by: 1) dematerialization of parts of economical processes so that they will not need physical moves and 2) improving the efficiency of production, distribution and consumption of goods and services, offering innovative monitoring, modeling, and decision support systems and technologies, by reducing demand for materials and physical goods (Maksimovic, Gavrilovic, 2016; Stock, Seliger, 2016).

Conclusion

This paper discussed only the technologies that are the most advanced in development now and those possible in the near future. There is still much more technological potential of mobility changing in other solutions tested by the IT and product engineers. This work concentrated also only on the solutions implemented by the enterprises which directly or indirectly operate within the urban spaces. The paper did not consider the IT solutions implemented by the cities itself building infrastructure enabling the city traffic managing by information collection, shares and flows.

The information technology enables the improvement of mobility patterns within urban areas in four main ways: 1) by reducing the number of cars and individual journeys; 2) by limiting the needs of movement per person; 3) by conversion of the mobility needs of the individual to change the structure of cargo transport which leads to change in the implementation of "the last mile" solutions; 4) by reduction of the needs of freight transport. Nowadays, solutions are mostly based on the real-time data flows and communications between people and enterprises with the use of many smart devices and sensors.

The information technology does not reduce the citizens' needs but influence on the ways of satisfying them. The idea is based 1) on the rule that it is possible to replace some of the physical needs with information flows and data access, and 2) on the rule that access to the information allows to make the movement process optimization according to the criteria of time, distance, cost, and frequency.

Concluding, the IT innovations, used in the logistics processes, influence the structure and number of resources mobility in urban areas. This way they will contribute to solving problems of congestion in urban areas in the future.

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