
Changes in Logistics Processes Caused by the Implementation of Automation in Transport

Submitted 10/06/22, 1st revision 30/06/22, 2nd revision 11/07/22, accepted 30/07/22

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Abstract:

Purpose: The purpose of this article is to present a more general aspect of the considerations regarding changes in logistics processes caused by the implementation of automation in transport. We believe that the automation of logistic processes is an indispensable and inevitable, although not the only, condition for the development of economic activity in the Polish TSL sector.

Design/Methodology/Approach: Statistical information collected from available sources and reports is the basis for the analyses presented in the article. The primary research method is observation, analysis, and inference. Available source materials from Polish statistical institutions and ministerial ones have been analyzed as well as the industry transport journals. Regarding the research topic, the analysis of the available specialist literature and web data was carried out.

Findings: The analysis made by the authors clearly shows that automation in the TSL industry systematically and effectively displaces logistical processes previously handled only by people, especially in cargo transport and warehouse logistics.

Practical implications:

Originality/Value: The insufficient number of studies illustrating the changes in TSL sector due to the automation in transport. Many detailed threads have only been mentioned and are waiting for further development.

Keywords: Management, transportation, road transport, logistics centers, Connected Automated Driving, CAD, collaborative robots, GDP, car fleet, road infrastructure, Autonomous car, Platooning, Personal Rapid Transit.

JEL codes: L91, N74, O18, R41, R42.

Paper Type: Research Paper.

Funding: The article was written as part of the research project "AV-PL-ROAD-Polish way to automate road transport" implemented in the Motor Transport Institute in Warsaw.

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1. Introduction

In 1984, the British 74-year-old Jane Snowball chose food products such as cereals, eggs, and margarine via teletext using a television remote control, placing the first remote order on a TV screen. Nearly 40 years later, only technology experts know about the teletext, and orders are placed via cell phones, which we also use to pay for them and open a box in a parcel machine. Such an order will be prepared by robots cooperating with humans (Kołata, 2021). The automation of logistic processes, which translates into everyday life, is galloping exponentially, and changes are noticeable at almost every step. Other authors noticed and signaled these processes several years ago (D'Onofrio and Meihardt, 2020). Therefore, the direction of change and development of automation in transport, forwarding, and logistics (TSL) became the subject of research and analysis performed by the authors.

In recent years, the automation of transport processes in the world, and thus also in Poland, has been developing systematically and dynamically. However, there has been a lack of reliable and synthetic analysis of the extent of the changes in recent years and of conclusions and forecasts regarding the dynamics of these changes in the near future. The authors decided to exploit this research gap and have analysed the automation and its impact on transport logistics processes. The article is aimed at transport development researchers, students, and TSL entrepreneurs.

This article discusses problems related to changes in logistics processes due to the implementation of automation in transport. Arguments were presented that the implementation of automation in the TSL industry is a factor in the development of the entire Polish and world economy. The purpose of this discussion is to point out a more general aspect of the determinants of changes in logistics processes caused by the implementation of automation. We put forward the thesis that automation of logistic processes is a necessary and inevitable, although not the only, condition for the development of economic activity in the Polish TSL sector. The research questions that were developed are:

1. What are the contemporary processes and logistics chains and what is the the aspect of their automation?
2. What is the impact of automation on the development of supply chain logistics?
3. What are the possible benefits of automation in the TSL industry?

The whole article ends with a summary and conclusions. The analyses were based on literature analysis and statistical information gathered from available sources and reports. The main research method was the observation, inference, and evaluation. The information presented should be seen as an outline of the problem addressed and as a contribution to a wider discussion.

2. Modern Automation of Logistics Processes

Logistics is the supply chain management process. By definition, the term “supply chain” is understood to mean activities related to the movement of products and services, from their original source, through all intermediate forms, to the form in which products and services are consumed by the customer. Logistics is therefore about integrating management into traditional production, finance and marketing areas. The necessary condition for creating the supply chain is the storage and transport chain, also called the logistics chain. The logistics chain is such a warehousing and transport chain, which is a technological connection of storage and transshipment points with the freight transport routes and organizational and financial coordination of operations, ordering processes and inventory policy of all links of this chain (Logistyka, 2010).

Since the functioning of a logistics chain is determined by its spatial distribution, the term supply chain should be understood as the flow of logistics products within a well-defined logistics network configuration. The implementation of automation in the TSL industry streamlines and modifies the existing perception of logistics processes.

Autonomous transport both inside and outside of logistics and warehousing centres is increasingly used. In the near future, the supply chain will take the shape of an impersonal cycle of activities starting with the delivery of goods by autonomous vehicle to the warehouse, where cognitive robots will complete the order, modern sorters will redirect it accordingly, and the autonomous vehicle (car or drone) will deliver the package straight to the trunk of the car or directly to the house using a one-time access code (Bray and Cebon, 2022).

In recent years, the greatest impact on the evolution of logistics chains and processes is exerted precisely by developing new technologies and replacing humans with machines. Automation, artificial intelligence (AI), Machine to Machine communication technologies, the Internet of things (IoT) (Cao *et al.*, 2020) and its use are a major part of the digital transformation occurring in today's TSL industry.

In this respect, it is important to remember that technological change, while very dynamic, requires time to implement. The full adoption of autonomous vehicles will occur between 2030 and 2040 due to the economic calculus (Brdulak and Zakrzewski 2013), i.e. the cost of end-of-life for non-autonomous vehicles, the need for autonomous vehicles to adapt to freight transport and to achieve their expected performance and safety standards in operation. However, autonomous fleets known as Connected Autonomous Vehicles (CAV) will become more widely used and help fill transit gaps or provide dedicated solutions for large enclosed areas such as airports (Lin *et al.*, 2020), university campuses or technology parks.

Today, automation is one of the most important trends in technology development and consists of almost total automation of the workflow using Machine Learning (ML) and artificial intelligence (AI) (Echelmeyer, 2008). Automation combines modern technology, intelligent enterprise management software, and tools that enable full automation of complex business processes. Automation can effectively recognize, analyze, design, measure, monitor, and evaluate the stages of logistics processes.

The market for solutions needed to implement autonomous transport in 2020 was worth around USD 55 billion and is expected to exceed USD 556 billion in 2026 (Darowska *et al.*, 2020). The 5G network, which will facilitate data transfer between vehicles and infrastructure, will be very helpful for the introduction of autonomous solutions. As autonomous driving technology becomes more widespread, the fleet of autonomous vehicles increases, the document known as a driver's license will become obsolete in the future in about 15-20 years.

The introduction of automation of manufacturing processes in the industry is particularly evident in the automotive industry. Nowadays, the production of one car takes on average about 14 to 30 hours and there are many more robots than people working in factories. Different is the case with luxury brands (e.g., Rolls Royce or Bentley), where it can take 650 manhours (82 days) and a Bugatti is even 6 months of work where 20 craftsmen assemble from more than 1800 elements the strongest, fastest exclusive sports car in the world. However, luxury vehicle production is a fraction of overall production, so the automotive industry is leading the way in implementing production automation solutions.

Robots replacing humans are also becoming cheaper and faster. Their precision and "intelligence" are increasing. They can work almost 24 hours a day, do not get tired, do not get sick, and do not need a lunch break. Investment in robots is more profitable than hiring people, for example, during a virus pandemic. The list of jobs that cannot yet be automated is decreasing from year to year.

The goal of robotization and automation of logistics processes is to replace repetitive, too difficult or dangerous human work with robotic work. Robots perform their tasks with greater precision, repeatability and strength, and can work almost without interruption. Robotization increases productivity and the ability to achieve results that people cannot achieve. That is the reason for the increasing use of robots in industry and various logistics processes.

Packaging and palletizing robots, autonomous guided vehicles (AGVs), and cobots, i.e., collaborative robots (Collaborative Robot), have become commonplace in logistics and warehouse centres. The main spheres of the economy in which robots (cobots) have the greatest potential for development are transport, the flow of raw materials, semi-finished products, products and their packaging. These tasks are

handled by mobile robots, which significantly improves logistics processes. For effective operation, machines need to meet the following conditions:

- they must be able to receive information from the environment,
- work for a long time without human intervention,
- navigate in an environment allowing for a certain degree of variability without human assistance,
- avoid situations that are dangerous to people, animals, things, the environment, and themselves.

By 2023, the market for robots operating in the logistics industry will be worth USD 80.64 billion. It is estimated that the number of robots working in warehouses will increase to 4 million in 2025. In logistic centres, robots can perform standardized tasks such as collecting or transferring goods (Zakrzewski, 2016). The capacity of a manufacturing line when a robot replaces a worker might increase by even 40%.

AGV robots do not require direct control, but they move autonomously based on the identification of relevant points in the field and an electronic map of the warehouse, which becomes a reference for the robot's activities. Using 3D scanning technology, the machine identifies obstacles and acquires the data needed to create the map.

Once a warehouse (or other space, such as a shop floor) is mapped, the robot can easily determine the shortest path between two points (pick-up and delivery point). Thus, automation is increasingly influencing the efficiency of logistics and warehousing centres (Zakrzewski, 2016). The first associations with automation are usually unmanned vehicles: trucks, ships or airplanes, but of great importance is the automation in confined spaces in handling terminals and warehouses, which may be less spectacular, but is no less important. Automation optimizes the unmanned manoeuvring of swap containers at the terminal - putting them into the gate, unloading, putting away, and also the movement of unloaded pallets in the warehouse. These activities can be performed by robots and autonomous devices - without human hands, but under human supervision.

There are already plenty of examples of automation being applied to logistics processes. The logistics operator from Wrocław - Logbox teamed up with the company Sente to implement the management system high-storage warehouse. The work resulted in creating a solution tailored to the specific nature of the client's unique processes, which translated into a significant increase in the efficiency of warehouse operations (Operator, 2021).

In Poland, at the beginning of 2018, only about 15% of warehouses were mechanized, and only 5% automated, while the remaining 80% operated without any automation. In other words, people still play key roles in warehouse operations. In large distribution centres, logistics, warehouses (Nowacki and Zakrzewski, 2016)

and factories can be up to 1,000 employees, whose job is to unload, load, sort and pack items of non-standard sizes or shapes. Machines can do these jobs.

According to data, at the end of 2018, there were only 42 robots per 10,000 employees in the industrial processing sector in Poland. This is far less than in Germany (338), and even in the Czech Republic (135) and Hungary (84). In total, more than 13,600 industrial robots were used. Nearly 40% were in the automotive industry owned by foreign corporations. Only 6% of all businesses in Poland use (2020) industrial or service robots (Grzeszczak *et al.*, 2019).

Palletising robots are increasingly used, making it possible to prepare so-called mixed pallets, consisting of many different goods, which are picked by the robot directly from homogenous pallets. The digitization of processes will progress, aiming to reduce the involvement of human resources. In terms of automation, there has been an increasing adoption of advanced IT solutions such as platforms that automatically provide information to customers, platforms that show estimated delivery times.

From the perspective of warehouse automation and robotics: devices that measure shipments, autonomous or semi-autonomous forklifts, as well as "cobotic" arms, Internet of Things (IoT) sensors, and many other solutions that increase the efficiency of warehousing and transportation processes are being implemented. Since 2017, the Polish VersaBox system has started automating transport in warehouses Versabox and cooperated with Faurecia, Autoliv, Huf, among others. Automated mobile robots, also known as AMRs, are increasingly being used in warehouse operations.

3. The Impact of Automation on the Development of Logistics in the Transport Chain

Automatic storage systems used more and more often in the economy are characterized by the complete elimination of human participation in the processes of movement and storage of goods. Automation increases the efficiency of warehouse operations, increases the ratio of warehouse cubic capacity utilization, reduces facility maintenance costs, eliminates errors, and improves health and safety. However, this is also a risk because complete automation entails high initial investment costs and the inability to control the warehouse in case of system failure manually.

Autonomous road, air, and rail transportation is developing. The representatives of unmanned aerial transport are drones, used in projects by Amazon and Google, for example. Drones are being developed as autonomous transportation or support elements handling processes in conjunction with conventional methods and means of delivery. Many formal and legal issues regarding the deployment and use of drones and autonomous vehicles in urban spaces have not yet been resolved; hence it is too

early to evaluate these modes of transportation as an alternative to current vehicles and transportation facilities. That should be considered a perspective at least over the next 5-10 years. The necessity of introducing autonomous vehicles in modern logistics has already been noticed in the literature on the subject (Lin *et al.*, 2020).

However, autonomous vehicle transportation of cargo has been growing. In September 2016, Mercedes-Benz Vans showed the Vision Van concept vehicle in Stuttgart, which can be successfully used in the supply chain, for example, in the "last mile" delivery, including inner-city areas. Its electric motor has an output of 100 hp. The maximum speed of the vehicle (without the speed limiter) is 120 km/h and with a speed limiter 80 km/h. The Vision Van can travel from 80 to 270 km on a single charge, depending on surrounding conditions (Mercedes-Benz, 2021).

The EinRide T-Pod autonomous truck, on the other hand, has a maximum capacity of 20 t and will fit in 15 Euro pallets. Its propulsion is based on electric motors, which on a single charge of the lithium-ion batteries, allow a range of 200 km at a top speed of 85 km/h. The truck is equipped with an autopilot and a remote control system that allows the operator sitting in the office to take control of the T-Pod. One operator can supervise several trucks in this way, and his location can be up to several hundred kilometres away from the trucks. Vehicle dimensions are approximately 7x2,5 meters. No cab allows the vehicle to be shorter than a traditional truck while providing more cargo space (D'Onofrio and Meihardt, 2020).

Once they meet safety requirements, these types of autonomous vehicles can be an excellent way to bridge the gap in cargo transportation between manufacturers or factories and warehouse and logistics centres (Zakrzewski, 2016). Their role will increase as there is a shortage of drivers in the labour market and employing them generates certain costs. Therefore, the use of autonomous vehicles on the road may be beneficial for manufacturers and companies in the TSL industry.

The widespread use of autonomous cars will have a significant economic dimension to reduce fuel and transportation costs by 5 to 30% in supply chains. In total, up to €30,000 in savings per vehicle can be achieved annually. Autonomous trucks can be on the road for up to 24 hours a day without a break, saving time previously spent on breaks for the driver. Nearly 3.3 million trucks are currently registered in Poland. If 1 million autonomous cars appeared on Polish roads, shipping companies could save a massive amount of €30 billion.

In individual companies, automation will help strengthen competitiveness. Entrepreneurs can resort to it in order to: increase productivity, minimize human error, increase the level of repeatability of processes and increase safety. Automation allows for significant time savings and much greater accuracy than manual operations. Companies are also automating their processes to replace labour shortages with machines, to become immune to staff turnover and to reduce labour costs (Andersson and Ivehammer, 2019).

The primary factors motivating logistics centre tenants to take advantage of automation are the desire to streamline logistics processes, build competitive advantage and generate savings by, for example, becoming independent of the labour market situation.

The shortage of qualified staff means that tenants automating their logistics processes may be guided primarily by the criterion of the attractiveness of a given location regarding its integration in the supply chain, i.e., proximity to suppliers and customers, rather than access to potential employees.

The use of automation in the warehouse environment is becoming standard, as many companies use software to sort or replenish goods. Limitations in the performance of the equipment (i.e., robots) and their high cost compared to human labour mean that the technology is not yet very widespread and is primarily limited to performing support tasks for workers. Autonomous vehicles will play an important role in logistics in the next 5-10 years.

The leaders in the use of automated machines are countries referred to as the Asian tigers: 37% is now the average annual growth rate of industrial robots in China from 2012 to 2019, 14% of the work in Singapore robots do in Q1 of 2020, and as many as 29% of Singapore's operations are projected to be performed by robots in 2021 (Grzeszczak *et al.*, 2019).

The developed economies of Europe have also relied on robotization. Thanks to the new instruments, the Italian government plans that purchases of machinery and equipment were 13% higher in 2017 than in 2016. Germany or the US have focused on solutions that address a very wide range of business activities and allow to obtain an exemption for investments in many categories of production facilities.

One of the important benefits is also increased active and passive driving safety. Vehicles with automatic driving systems can drastically reduce the number of traffic accidents and, therefore, death or injury by means of correct, economical, optimized driving, which represents a measurable financial benefit (Thompson and Brooks, 2010).

Another important advantage may be the reduction of congestion in cities. Autonomous vehicles by optimizing routes, avoiding traffic jams, driving with the best optimal speed can improve traffic capacity by approx. 20-25% (Sparowitz *et al.*, 2013).

In addition, as automation becomes more widespread, the cost of implementation decreases. With regard to the physical flows of goods in warehouses, unloading and loading processes and internal logistics processes will be automated based on technologies such as autonomous forklifts and solutions supporting shipment preparation processes.

4. Discussion

The analysis made by the authors clearly shows that automation in the TSL industry systematically and effectively displaces logistical processes previously handled only by people, especially in cargo transport and warehouse logistics. The authors believe that the competitiveness of the entire TSL industry and other industries in Poland will increase as the role of automation in logistics processes increases. Automated transportation and logistics infrastructure, as well as a sufficiently large fleet of autonomous vehicles and robots and cobots (and to a lesser extent drones), are necessary, though not the only, condition for faster development of the economic activity.

The impact of automation on logistics processes increases in proportional terms as the role of the human factor decreases. The number of autonomous vehicles is steadily increasing and this is followed by the modernization and expansion of modern road infrastructure. The insufficient and underdeveloped network of expressways and freeways adapted to the movement of autonomous vehicles in Poland, as well as their poor quality, may act as barriers to the increased mobility of the fleet of this type of vehicles (Zakrzewski and Szopik-Depczyńska, 2021).

The introduction of a large, modern fleet of autonomous vehicles in both intercity and urban transport operations can reduce congestion on the roads and lower transport costs, which is extremely important for owners of companies in the TSL industry. Automation optimizes the growth of transport costs, especially commercial road transport and thus reduces congestion and environmental pollution (Wang *et al.*, 2017). Lower emission of toxic fumes leads to the restoration of the environment and improves the quality of life of employees TSL industry and ordinary citizens.

The analysis of the authors has shown that the automation of logistics processes in the TSL industry has become today one of the most important elements of the development of the entire national economy. All this in the context of globalization, which, owing to technological advances and the development of the Internet, has reduced the distances between countries and people. Transport systems, as a result of progressive automation, in spite of language, cultural and geographical differences, are being increasingly developed and efficiently operated, which is facilitated by technological development (Lin *et al.*, 2020).

5. Conclusion

In recent years, road and motor transport in Poland has modernized, becoming an important part of the European Union transport system. The development of transport automation is facilitated by the transit location of Poland, located on major European longitudinal and latitudinal routes from west to east and from north to south, in the trans-European transport corridors. Advanced automated logistics centres are being built near modern roads and urban agglomerations. The analysis

presented in the article indicates that the automation of logistic processes in transport will dynamically progress in the perspective of several decades.

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