USING ARTIFICIAL INTELLIGENCE IN THE TSL SECTOR IN POLAND

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Purpose: The aim of the article is to indicate solutions using Artificial Intelligence (AI) within the transport, shipping and logistics (TSL) sector and to estimate their use in Poland. In addition, the analysis included an assessment of the benefits in the perspective of Polish enterprises.

Design/methodology/approach: The two step research procedure included a literature review and an empirical study using the CATI method within TSL companies in Poland was conducted. Based on the results six most common possibilities of using artificial intelligence in the TSL industry were analysed. Afterwards, the author subjected all variables together to determine those that are currently most important for the analysed enterprises.

Findings: The six possibilities of using AI in TSL sector were identified (personalization and customer service, analysis of financial data, data analytics, optimization of energy and resource consumption, decision-making process and transport routes planning and monitoring deliveries) and then analysed from the perspective of company type, market of functionality and origin of capital. According to the results there is an impact of using AI in TSL on economic efficiency and transportation risk management. The individual attitude of each executive to the use of AI in the TSL sector is rather positive, however statistically the implementation of AI is related to the approach to AI of decision-makers only in the case of organisations with foreign capital.

Research limitations/implications: This article has its limitations; the author plans to repeat the studies in the future to see the changes taking place in this area.

Practical implications: The conclusions may be useful for entrepreneurs from the TSL industry who are considering implementing artificial intelligence in the operations of their organisations.

Social implications: The findings are important for public entities responsible for the regulations of AI implementation and use in the TSL sector as well as for employees who work in areas where AI can be a support.

Originality/value: The possible actions presented in this paper, in which AI can play a role in the TSL industry, are a current and promising topic in supply chain management. Results are mainly addressed to TSL companies, digital tools distributors, logistics and supply chain managers.

Keywords: digital logistics, digital solutions, AI in supply chains, attitude towards digitalization, trends in TSL.

Category of the paper: research paper.

1. Introduction

In today's world, Artificial Intelligence (AI) is a key element in creating innovative solutions that change the way businesses operate in many industries, including transport, shipping and logistics (TSL) (Boute, Udenio, 2023). Generally, an increasing interests follows the need to ensure: efficiency optimization and automation, predictive analytics and enhance supply chains stakeholders' experience and sustainability.

According to the European Parliament's definition, "AI is the ability of a machine to display human-like capabilities such as reasoning, learning, planning and creativity" (European Parliament, 2023). This ability of the system to properly interpret data obtained from external sources, learn from them and use this acquired knowledge to perform specific tasks and achieve the intended goals through flexible adaptation is developing very dynamically (Pournader et al., 2021; Toorajipour, 2021).

Various AI concepts include machine learning, neural networks, robotics, natural language processing (NLP), and data analytics. Machine learning allows systems to learn from data and experience. Neural networks act as computer brains, helping with image recognition or language understanding (Portal Sztucznej Inteligencji, 2024). Robotics in the context of AI involves the creation of robots capable of physical or intellectual tasks. Natural language processing enables communication between computers and humans, while data analysis helps discover patterns in large sets of information. Process automation, intelligent system development, data analytics, and the development of AI-powered services are restructuring the industry, creating new job opportunities while also posing challenges to adapt to these changes.

The use of AI in logistics affects the optimisation of transport routes, delivery time and cost, as well as warehouse management, including inventory management and reduction of operating costs, as well as fleet management (Mroczko, 2023). By monitoring fleet costs and performance, machine learning algorithms can analyse data on fuel consumption, vehicle health and traffic patterns to optimise route and driving style, leading to fuel and operating cost savings. The use of AI has an impact on improving reactivity and flexibility, which allows companies to quickly respond to changes, failures or non-standard situations. This allows companies to be more flexible and adapt to changing conditions quickly and effectively, while increasing their market competitiveness.

In terms of return shipment and complaint management, AI can identify products, manage returns, and handle complaints. This allows companies to deal with problems and maintain a good relationship with the customer quickly and accurately. An important benefit is therefore the ability to improve the quality of customer service, which contributes to increasing customer trust and building a positive image of the company (Naz et al., 2021).

Moreover, computers can analyse vast amounts of data, detect patterns, predict trends, and make decisions based on logical reasoning. Therefore, they have an impact on improving the accuracy of demand forecasting, thanks to the analysis of historical and current data, which allows for more accurate adjustment of inventory levels and minimises the risk of excess or

insufficient inventory (Helo, Hao, 2022). In addition, AI also enables faster threat detection and response to cyber threats and crises.

AI can also support the drive to protect the environment by analysing and optimising operational activities and processes, e.g. energy production or waste management. As a result, it is possible to achieve sustainable development and protect natural resources and biodiversity (Tsolakis et al., 2021).

The aim of the article is to indicate solutions using AI within the TSL sector and to estimate their use in Poland.

The following research questions were posed:

RQ1: In which areas and to what extent do companies from the TSL industry use AI?

RQ2: Does the use of AI have an impact on economic efficiency?

RQ3: Does the use of AI have an impact on transportation risk management?

RQ4: What is the individual attitude of each executive to the use of AI in the TSL sector?

In addition, the analysis includes an assessment of the benefits in the perspective of Polish enterprises.

2. Methods

In order to achieve the aim of the article, the first step was to conduct a literature review. Based on the results, the questionnaire was prepared. The second step of the research procedure was to conduct an empirical study using the CATI method. The survey was conducted in the second quarter of 2024 in a group of 100 companies from the TSL sector with a minimum of three years of experience in the industry. This selection was deliberate, only organisations with experience in the industry were analysed and new enterprises were excluded. The targeted selection for the research sample also included the exclusion of micro-enterprises, including sole proprietorships. The criterion of selecting a minimum of 11 employees in the organisation was used. Another criterion for the selection of the sample was an affirmative answer to the question whether the company implements modern solutions in the field of improving digital logistics methods or tools. The author of the article wanted to acquire companies with a certain degree of experience in the field of digitisation. The respondents were people holding middle and high-level managerial positions.

The survey was conducted on a sample of 100 enterprises, among which half (54% of the sample) were enterprises employing from 11 to 50 employees, 30% medium-sized enterprises and 16% large enterprises employing more than 500 people. 67% of the sample were companies with Polish capital, 23% with mixed capital and only 10% with foreign capital. The companies operate on the national and international B2B and B2C market. Subsequently, the database of results was subjected to a statistical descriptive analysis, focusing on the research questions.

3. Results

3.1. The areas using AI by companies from the TSL industry

To answer the first question RQ1 (In which areas and to what extent do companies from the TSL industry use AI?), the author decided to select possible applications of AI implementation in the activities of companies in the TSL sector. Each question was then evaluated in the study and conclusions were developed. Firstly, each of the possibilities was analysed from the perspective of the size of the company, considering the criterion of the number of employees. The next variable was the origin of the company's capital. The third was the market for the operation of the business in terms of its type.

Based on the literature review, six most common possibilities of using artificial intelligence in the TSL industry were analysed. The exact data are indicated in Tables 1-6. Afterwards, the author subjected all variables together to determine those that are currently most important for the analysed enterprises.

Table 1.
Leveraging AI to improve personalization and customer service – the perspective of analyzed TSL companies

		Leveraging AI to improve personalization and customer service					
		1	**2**	**3**	**4**	**5**	**Total number of companies**
Number of employees in the Company	11-50 employees	9	12	12	17	4	54
	51-249 employees	3	3	17	5	2	30
	more than 250 employees	1	2	7	5	1	16
	Total number of companies	13	17	36	27	7	100
Origin of capital	national	7	5	16	9	3	40
	international	2	4	2	4	-	12
	mix	4	8	18	14	4	48
	Total number of companies	13	17	36	27	7	100
Market of operation	B2B	5	6	15	13	3	42
	B2C	2	3	8	-	-	13
	B2B and B&C	6	8	13	14	4	45
	Total number of companies	13	17	36	27	7	100
	national	7	5	16	9	3	40
	international	2	4	2	4	-	12
	mix	4	8	18	14	4	48
	Total number of companies	13	17	36	27	7	100

Source: own elaboration, N = 100.

Based on the results of the study, it can be concluded that the leveraging AI to improve personalization and customer service is used in the medium and large extent in the TSL industry (see Table 1). This can affect customer satisfaction and loyalty. AI can analyze customer data, including purchase history and preferences to create more personalized transactions experience. AI-driven chatbots can provide instant support, enhance response times and availability. AI can also adjust pricing in real-time based on demand, customer behavior and competitor

pricing. AI can also track and analyse customer interactions across multiple channel, omnichannel, helping to enhance relationship management.

Table 2.
The use of AI supports the analysis of financial data – the perspective of analyzed TSL companies

		The use of AI supports the analysis of financial data					
		1	**2**	**3**	**4**	**5**	**Total number of companies**
Number of employees in the Company	11-50	12	4	18	13	7	54
	51-249	6	6	11	6	1	30
	more than 250	2	2	5	6	1	16
	Total number of companies	**20**	**12**	**34**	**25**	**9**	**100**
Origin of capital	national	17	6	23	14	7	67
	international	2	3	1	3	1	10
	mix	1	3	10	8	1	23
	Total number of companies	**20**	**12**	**34**	**25**	**9**	**100**
Market of operation	B2B	10	2	13	13	4	42
	B2C	2	4	6	-	1	13
	B2B and B&C	8	6	15	12	4	45
	Total number of companies	**20**	**12**	**34**	**25**	**9**	**100**
	national	10	2	13	13	4	42
	international	2	4	6	-	1	13
	mix	8	6	15	12	4	45
	Total number of companies	**20**	**12**	**34**	**25**	**9**	**100**

Source: own elaboration, N = 100.

The results show that TSL companies use AI to analyse financial data (see Table 2). It offers various advantages. First, enterprises can forecast future trends and adjust investment strategy more effectively. Second, AI can help to identify unusual patterns and anomalies to enable real-time detection of fraud and consequently reduce financial loses. Then, AI can assess various risk factors. Finally, AI identify inefficiencies in spending and suggest cost-savings.

Table 3.
AI-powered data analytics helps detect potential vulnerabilities, security errors, and prevents leakage of customer data – the perspective of analyzed TSL companies

		AI-powered data analytics helps detect potential vulnerabilities, security errors, and prevents leakage of customer data					
		1	**2**	**3**	**4**	**5**	**Total number of companies**
Number of employees in the Company	11-50 employees	7	16	8	14	9	54
	51-249 employees	1	4	16	8	1	30
	more than 250 employees		4	2	7	3	16
	Total number of companies	**8**	**24**	**26**	**29**	**13**	**100**
Origin of capital	national	7	19	18	14	9	67
	international		4	2	3	1	10
	mix	1	1	6	12	3	23
	Total number of companies	**8**	**24**	**26**	**29**	**13**	**100**

Cont. table 3.

Market of operation	B2B	3	13	6	13	7	42
	B2C	1	2	9	1		13
	B2B and B&C	4	9	11	15	6	45
	Total number of companies	**8**	**24**	**26**	**29**	**13**	**100**
	national	2	10	11	12	5	40
	international	1	5	4	1	1	12
	mix	5	9	11	16	7	48
	Total number of companies	**8**	**24**	**26**	**29**	**13**	**100**

Source: own elaboration, N = 100.

The role of using AI-powered data analytics is less common than two here presented possibilities (see Table 3). Companies could profit more, enhance their security via implement real time and compliance monitoring, vulnerability assessment, automated incident responses, data loss prevention and make deeper analysis of stakeholders' behavior.

Table 4.
AI Uses Supports Optimization of Energy and Resource Consumption in Transportation – the perspective of analyzed TSL companies

		AI Uses Supports Optimization of Energy and Resource Consumption in Transportation					
		1	**2**	**3**	**4**	**5**	**Total number of companies**
Number of employees in the Company	11-50 employees	9	9	14	16	6	54
	51-249 employees	1	4	15	7	3	30
	more than 250 employees	2	2	5	6	1	16
	Total number of companies	**12**	**15**	**34**	**29**	**10**	**100**
Origin of capital	national	9	11	21	20	6	67
	international	1	3	2	3	1	10
	mix	2	1	11	6	3	23
	Total number of companies	**12**	**15**	**34**	**29**	**10**	**100**
Market of operation	B2B	6	7	12	13	4	42
	B2C	-	3	7	2	1	13
	B2B and B&C	6	5	15	14	5	45
	Total number of companies	**12**	**15**	**34**	**29**	**10**	**100**
	national	3	7	12	13	5	40
	international	2	3	3	4		12
	mix	7	5	19	12	5	48
	Total number of companies	**12**	**15**	**34**	**29**	**10**	**100**

Source: own elaboration, N = 100.

Considering today's energy challenges, the use of AI to optimize resource consumption is very important and used by companies in the surveyed sector (see Table 4). Generally, there are a few impactful ways. AI can analyze data from equipment and machinery to predict the maintenance needs. AI algorithms optimize energy usage in real time by adjusting lighting, heating and cooling based on occupancy patterns and weather. AI enhance the efficiency of energy distribution, resource allocation. It is also useful in simulation and modeling.

Table 5.
The use of AI supports decision-making in the choice of means of transport, delivery plan –
the perspective of analyzed TSL companies

		The use of AI supports decision-making in the choice of means of transport, delivery plan					
		1	**2**	**3**	**4**	**5**	**Total number of companies**
Number of employees in the Company	11-50 employees	9	11	8	18	8	54
	51-249 employees	3	3	8	14	2	30
	more than 250 employees	1	2	4	8	1	16
	Total number of companies	**13**	**16**	**20**	**40**	**11**	**100**
Origin of capital	national	10	11	14	24	8	67
	international	2	2	1	5		10
	mix	1	3	5	11	3	23
	Total number of companies	**13**	**16**	**20**	**40**	**11**	**100**
Market of operation	B2B	6	7	4	20	5	42
	B2C	1	3	4	4	1	13
	B2B and B&C	6	6	12	16	5	45
	Total number of companies	**13**	**16**	**20**	**40**	**11**	**100**
	national	2	8	7	19	4	40
	international	3	4		5		12
	mix	8	4	13	16	7	48
	Total number of companies	**13**	**16**	**20**	**40**	**11**	**100**

Source: own elaboration, N = 100.

Companies in TSL sector benefit of using AI to choose transport and create a delivery plan can that streamline operations (see Tables 5 and 6). Enterprises can easier gather data on routes, delivery times, traffic patterns, vehicle capacities and clients' locations. Algorithms help to find the most efficient routes and schedules. Moreover, the proactive planning can be implemented with the support of real-time adjustment and cost-effectiveness.

Table 6.
The use of AI allows to focus on optimal planning of transport routes, monitoring deliveries –
the perspective of analyzed TSL companies

		The use of AI allows to focus on optimal planning of transport routes, monitoring deliveries					
		1	**2**	**3**	**4**	**5**	**Total number of companies**
Number of employees in the Company	11-50 employees	6	11	15	16	6	54
	51-249 employees	2	4	11	11	2	30
	more than 250 employees	1	1	4	7	3	16
	Total number of companies	**9**	**16**	**30**	**34**	**11**	**100**
Origin of capital	national	8	11	21	21	6	67
	international		4	1	5		10
	mix	1	1	8	8	5	23
	Total number of companies	**9**	**16**	**30**	**34**	**11**	**100**
Market of operation	B2B	5	8	8	18	3	42
	B2C		2	7	3	1	13
	B2B and B&C	4	6	15	13	7	45
	Total number of companies	**9**	**16**	**30**	**34**	**11**	**100**
	national	3	4	11	19	3	40
	international	2	4	3	3		12
	mix	4	8	16	12	8	48
	Total number of companies	**9**	**16**	**30**	**34**	**11**	**100**

Source: own elaboration, N = 100.

Moreover, the author has compiled all the variables to indicate those that are currently the most important for the analyzed enterprises of the TSL sector (see Table 7).

Table 7.
The descriptive statistics of the use of AI – the perspective of analyzed TSL companies

	Descriptive statistics								
	Average	**Median**	**Moda**	**Count**	**Min**	**Max**	**Bottom**	**Top**	**Standard deviation**
Leveraging AI to improve personalization and customer service	2,980	3	3	36	1,0	5,0	2,0	4,0	1,119
The use of AI supports the analysis of financial data	2,910	3	3	34	1,0	5,0	2,0	4,0	1,240
AI-powered data analytics helps detect potential vulnerabilities, security errors, and prevents leakage of customer data	3,150	3	4	29	1,0	5,0	2,0	4,0	1,167
AI Uses Supports Optimization of Energy and Resource Consumption in Transportation	3,100	3	3	34	1,0	5,0	2,0	4,0	1,150
The use of AI supports decision-making in the choice of means of transport, delivery plan	3,200	4	4	40	1,0	5,0	2,0	4,0	1,223
The use of AI allows to focus on optimal planning of transport routes, monitoring deliveries	3,220	3	4	34	1,0	5,0	2,5	4,0	1,124

Source: own elaboration, N = 100.

The data presented in Table 7 indicate that two applications are the most important in the surveyed group of enterprises. First, the use of AI allows companies to focus on the optimal planning of transport routes, monitoring deliveries. Second, the use of AI supports decision-making in the choice of means of transport, delivery plan. Less important in the surveyed group of enterprises were: Leveraging AI to improve personalisation and customer service and the use of AI to support the analysis of financial data.

3.2. The impact of using AI on economic efficiency and on transportation risk management in the perspective of companies from the TSL industry

To answer the second question **RQ2** *(Does the use of AI have an impact on economic efficiency?)*, the author decided to verify the relation between using AI in the TSL companies' operations and economic efficiency (Q2: To what extent does the use of AI support economic

efficiency?). Based on the resulting data, the correlation coefficient was calculated using the Spearman rank order correlation. More precisely, Spearman's R coefficient = 0. 633505, with the denoted coefficient. correlations are significant with p <.05000, where T(N-2) = 8,105303. The relation is statistically significant and positive, i.e. when the rating in one area increases.

With the aim of answering the third question **RQ3** (*Does the use of AI have an impact on risk management*?), the author asked two questions to companies. Q1: *To what extent does the company use AI in its operations?* And Q2: *To what extent does the use of AI support transportation risk management?* Based on the resulting data, the correlation coefficient was calculated using the Spearman rank order correlation. More precisely, Spearman's R coefficient = 0.656152, with the denoted coefficient. correlations are significant with p <.05000, where T(N-2) = 8.607631. The relation is statistically significant and positive, i.e. when the rating in one area increases, the average score in the other does as well.

3.3. The attitude of using AI in the perspective of companies from the TSL industry

To answer the last question **RQ4**, (*What is the individual attitude of each executive to the use of AI in the TSL sector?*) First, the author of this paper deliberately selected a research group was deliberately selected that contained representatives of middle and high- level management. This ensured the results obtained were reliable.

Table 8.
The personal attitude of using AI in the perspective of companies from the TSL industry

		The individual attitude of each executive to the use of AI in the TSL sector					
		1	2	3	4	5	Total number of companies
Number of employees in the Company	11-50 employees	19	7	10	15	3	54
	51-249 employees	9	6	10	5	-	30
	more than 250 employees	3	3	3	4	3	16
	Total number of companies	**31**	**16**	**23**	**24**	**6**	**100**
Origin of capital	national	25	11	16	11	4	67
	international	2	2	3	3	-	10
	mix	4	3	4	10	2	23
	Total number of companies	**31**	**16**	**23**	**24**	**6**	**100**
Market of operation	B2B	17	6	6	10	3	42
	B2C	2	3	3	4	1	13
	B2B and B&C	12	7	14	10	2	45
	Total number of companies	**31**	**16**	**23**	**24**	**6**	**100**
	national	10	9	8	9	4	40
	international	4	1	5	2	-	12
	mix	17	6	10	13	2	48
	Total number of companies	**31**	**16**	**23**	**24**	**6**	**100**

Source: own elaboration, N = 100.

For most companies, the fear of implementing artificial intelligence is rather low. Detailed data are presented in Table 8. However, one of the respondents remarked *Personally, I am concerned about the implementation of AI in the company because of the risks associated with it replacing human work.*

Furthermore, the question of whether these people can have an impact on the degree of implementation of AI in the surveyed companies was analysed. According to the results of the research, there is a relationship between the original capital of the company represented by a given respondent and the degree of implementation of artificial intelligence. Based on the Kruskal-Wallis Test, significantly different distributions of responses in groups were identified. With regard to other variables (such as the size of the company and the market), no significant relationships were found, see Table 9.

Table 9.
Verification of the relationship between the companies' decision makers' attitude and the degree of implementation of AI

The criterion of typology of enterprises	H	p
Number of employees in the Company	H (2, N = 100) =2,717080	p = ,2570
Origin of capital	**H (2, N = 100) =6,117998**	**p = ,0469**
Market of operation	H (2, N = 100) =1,586939	p = ,4523
Market of operation	H (2, N = 100) =,5933023	p = ,7433

Source: own elaboration based on Kruskal-Wallis Test, N = 100.

4. Discussion

AI has the potential to support social, economic and ecological development in the TSL sector by improving efficiency, safety, sustainable development and education, as well as by creating new jobs and supporting small and medium-sized enterprises. In terms of fleet optimisation and management, AI can analyse real-time data such as road conditions, weather and traffic, allowing companies to reduce fuel consumption, delivery times and CO_2 emissions. This allows for appropriate preventive measures to be implemented, which increase road safety. The use of AI-based systems therefore has an impact on reducing transportation risk (Mentzer, 2021), which is confirmed by the results of the empirical research. AI can help monitor and reduce the carbon footprint by analysing data on energy consumption and emissions. Companies can use this information to introduce greener business practices, which support sustainability. This trend is also visible in the research of this article.

AI systems can improve communication and coordination between different actors in the supply chain (Richey et al., 2023). Automating logistics processes such as warehouse management, loading and unloading with the use of AI allows companies to increase operational efficiency. This makes it possible to better manage resources and to minimise

delays, which has a positive impact on the economy and the community, as it can lead to the creation of new jobs in sectors related to technology and management (Klumpp, Ruiner, 2022). It is not surprising that small and medium-sized enterprises do not differ much from large enterprises in their approach to the implementation of AI. In the TSL sector AI can support small and medium-sized enterprises, offering tools for market analysis, process optimisation and customer relationship management. This can contribute to their development and competitiveness in the market. AI can also support training programs for employees of the TSL sector, offering personalised training modules, simulations, and e-learning. This helps in improving professional qualifications and adapting to new technologies. According to the results of the survey, the attitude of decision-makers in the TSL industry is rather positive, there are no clear concerns regarding the implementation of AI (Brau et al., 2023). Therefore, it can be concluded that managers see more opportunities related to the implementation of this type of solution than threats.

5. Summary

The use of AI in the activities undertaken by the TSL industry is noticeable and multidimensional. Most often, companies used the potential for economic optimisation, but there is also potential to optimise activities aimed at meeting ecological and social postulates. The implementation of AI in the activities of companies from the TSL sector is conditioned by the approach to AI of decision-makers in the case of organisations with foreign capital. Other criteria, such as the size of the company and the market of operation, do not play a major role.

The possible actions presented in this paper, in which AI can play a role in the TSL industry, are a current and promising topic in supply chain management. AI will surely introduce an element of creativity and increase the capacity to generate fresh ideas which could entail devising entirely new sourcing, procurement and inventory management strategies. Results and conclusions are mainly addressed to TSL companies, digital tools distributors along with logistics and supply chain managers.

However, the article has its limitations- perspective of one country-the author plans to repeat the studies in the future to see the changes taking place in this area. It would also be interesting to conduct and compare the results of research from another country.

The author is interested in future research on the possibility of using AI throughout the supply chain, the impact of the use of AI in the pursuit of sustainable development, as well as circularity. It is crucial to use AI responsibly and ethically to ensure the harmonious development of this revolutionary field and to achieve benefits for society. It is worth remembering that the large-scale introduction of AI requires the consideration of ethical and

safety issues (von Krogh, 2023). The use of AI can have a positive impact on the quality of life, business efficiency and global development. For now, however, it is not known whether these benefits will also cover the long-time horizon.

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