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ENVIRONMENTAL AWARENESS OF GEN Z: A CREDIBLE AND PERSUASIVE ECO-FRIENDLY LAST-MILE DELIVERY MESSAGE SUPPORTED BY AI

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ABSTRACT: Last-mile delivery is the most complex and costly stage of the supply chain, where sustainability considerations are gaining strategic importance. Eco-friendly logistics solutions are increasingly valued, especially by Generation Z, digital natives actively engaged in online purchasing and highly sensitive to environmental issues. Artificial Intelligence (AI) supports this process by analysing consumer behaviour and message performance, enabling personalised communication. The purpose of this study is to explore the characteristics of credible and persuasive eco-friendly delivery messages in the context of sustainable development for Gen Z. The findings indicate that two message types are most influential: Eco Signals (symbols, colours, emotional language) and Sustainability Indicators (carbon footprint data, CO₂ reduction rates). The most effective messages combine both elements. A model message structure and the scope of AI-based analysis are proposed. The study confirms the importance of personalised sustainability communication for Gen Z and the need for further empirical research.

KEYWORDS: Generation Z, last-mile delivery, sustainability, eco-friendly delivery options using AI

Introduction

Last-mile deliveries are a key stage in the supply chain, responsible for delivering goods from local distribution centres directly to end recipients. It is also the most expensive and complicated part of the logistics process, and the aspect of sustainable development is becoming a priority in this area. In the coming years, the further integration of modern technologies will certainly be expected, such as artificial intelligence (AI), in logistics processes. This will allow for even better route optimisation, fleet management and increased customer satisfaction.

Last-mile logistics, therefore, faces many challenges, but thanks to innovative technological and ecological solutions, it is possible to meet the growing expectations of the market and care for the natural environment. These requirements and EU directives, along with lifestyle and trends, force eco-attitudes in every aspect of life, also when it comes to purchasing decisions and choosing delivery options. An example is Generation Z (Gen Z), which demonstrates a strong preference towards eco-friendly and environmentally conscious solutions in their e-commerce and online purchasing behaviours, in marked contrast with the approach of older generations (Ridwan et al., 2025).

It is worth noting that Gen Z – young adults born between 1995 and about 2010 (Krzyżanowska et al., 2024) – is the first generation of “digital natives”, raised with a smartphone in hand and with natural access to the Internet. Their presence in e-commerce introduces new rules, both for sellers and for the entire supply chain. Gen Zers spend the bulk of their lives on the Internet, on social media and chats. While giving them considerable knowledge about the world, at the same time, this exposes them to the influence of false information and content generated by algorithms. Among other things, Gen Z sees the growing negative effects of mass production and consumption on the environment and unfair practices of corporations, which is why they seek to make more conscious and ethical consumer decisions (Grabiwoda, 2019; Krzyżanowska et al., 2024). This is why the area of interest of the researchers of the study was Generation Z, because Gen Z is the generation that scientists currently predict will have to face the profound natural changes taking place on Earth (Nowak et al., 2023).

The purpose of this article is to present the features of a credible and persuasive eco-friendly delivery message in the context of the idea of sustainable development for Gen Z. The problem is discussed from the perspective of young adults, who are over 18 years old and under 30 years old, making purchases via the Internet. The main research focus is on seeking answers to the following research questions:

- RQ1: Do Generation Z consumers feel that their purchasing choices regarding last-mile delivery have a real impact on the natural environment?
- RQ2: What features must a message meet to convince Generation Z to choose a more environmentally friendly delivery option?
- RQ3: Will a message that includes the features indicated by the Generation Z surveyed here change their minds and be willing to choose a longer waiting time for a shipment, knowing that the decision will have a significant, positive impact on the environment?
- RQ4: How can AI be used to prepare a credible and persuasive eco-friendly delivery message?

Figure 1 outlines the structure of the article, detailing its key chapters and stages of research, with the aim of facilitating an understanding of the links between them.

The paper begins with an introduction (Chapter 1), which outlines the importance of the topic. This is followed by an overview of the literature (Chapter 2), discussing the latest trends in last-mile delivery, sustainability in e-commerce, and the approach of Generation Z to changes in their purchasing decisions and habits. Next, the research methods (Chapter 3) are described, including the procedures used, the sample and data collection process, and the characteristics of the respondents. The results chapter (Chapter 4) presents empirical findings, with the focus placed on the research process, combining the findings from both stages. This leads to the discussion (Chapter 5), where the results are analysed, and the limitations of the research are acknowledged, suggesting directions for future research. The respondents' answers constitute a valuable source of information about Gen Z's approach to sustainable development and awareness of decisions made at the stage of last-mile deliveries. The article ends with a conclusion (Chapter 6), summarising the key findings and formulating a credible and persuasive eco-friendly delivery message to engage Gen Z customers. The structure of the paper follows a logical flow from problem identification and literature review to research execution, analysis and final conclusion.

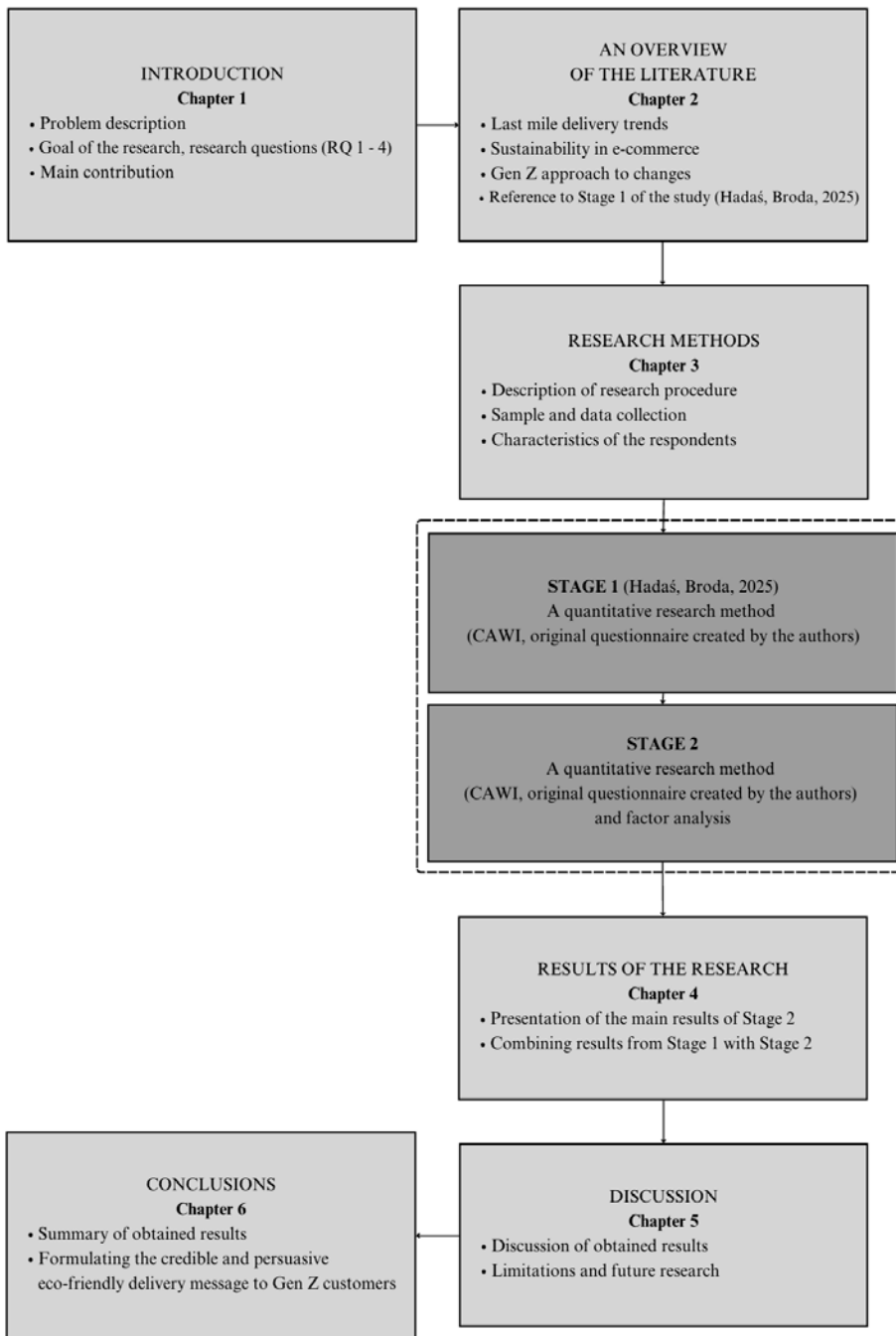


Figure 1. Structure of the article

An overview of the literature

Nowadays, the topic of sustainable development plays a key role in almost every area of life, focusing on supply chains and logistics. This applies especially to activities leading to the reduction of carbon footprint and inefficiency (Dey et al., 2011). At the same time, given the growing emphasis on conducting business in accordance with sustainable development, numerous challenges arise to effectively combine the optimisation of key indicators: delivery costs, time and range (Boysen et al., 2021). There is no doubt that e-commerce has exploded, transforming the retail landscape at a break-neck pace, with the result that while brick-and-mortar shopping is still the dominant purchasing method, e-commerce platforms are changing the behaviour of end consumers (Bouhouras et al., 2024).

Thanks to technological and communication developments, e-commerce has also developed, and now purchases can be delivered to customers' homes or to collection points such as parcel lockers, via delivery routes that cannot always be optimised (Comi & Nuzzolo, 2016). Courier companies, adapting their offer to changing conditions, implement new innovative solutions that allow for increasing the efficiency of last-mile transport and ensuring high-quality services expected by customers (Białokozowicz & Ryciuk, 2022).

The transportation, shipping and logistics (TSL) industry is constantly developing, and competitiveness is increasing, while fuel and employment costs are rising. The COVID-19 pandemic and the outbreak of the war in Ukraine caused the collapse of global supply chains, and companies operating in this area were forced to respond quickly to the changing business environment and macroeconomic factors. It can be seen that the main response of enterprises to these changes was to implement innovative solutions aimed at minimising costs and using modern technology (Zaborowski & Antonowicz, 2023).

Moreover, with Green Supply Chain Management (GSCM) in mind, it includes the integration of environmentally friendly practices with the traditional supply chain in order to achieve sustainable development (Nozari et al., 2021). Taking into account the concept of sustainable development, AI-based solutions play a crucial role in promoting this concept in e-commerce, especially through supply chain optimisation. Thus, AI and big data analytics in e-commerce support the balance between operational efficiency and ecological responsibility (Ragin-Skorecka et al., 2024). This means that integrating AI algorithms into operational management promotes eco-friendly business models while minimising energy consumption and environmental impact, which is in line with the Sustainable Development Goals (Chen et al., 2024; Fozooni et al., 2024; Ragin-Skorecka et al., 2024). In addition to digital strategy, basic technologies are crucial for green and sustainable performance, as advanced technologies such as IoT, cloud, big data and AI facilitate the flow and management of enterprise data (Nozari, 2024). Digital transformation strategy in the new era can create new business models that provide a new green and sustainable perspective for companies to use the generated data for strategic positioning as a green and environmentally friendly operation in the market (Mahajan, 2024).

The article analyses the problem from the perspective of Generation Z. So far, scientific research has focused primarily on examining the level of students' ecological awareness and promoting the idea of sustainable development (Burkholder et al., 2017; Akrof et al., 2019; Nowak et al., 2023; Hadaś & Broda, 2025). An important factor that distinguishes Gen Z from other generations is the awareness of global political and economic problems. Its representatives have a pessimistic attitude to reality, pointing to instability and uncertainty about their future (Paczka, 2020). The consumption model of Gen Z is deeply embedded in virtual reality and is based on mobile technologies. Young consumers move freely on the web and treat the Internet as the most convenient and cheapest form of making purchases, which they make using smartphones and tablets. They use them on a far wider scale than older generations, which is described as a "change in the paradigm of consumer functioning on the market" (Kozłowski & Rutkowska, 2016).

Considering the fact that Gen Z will have to face profound natural changes occurring on Earth in the future, it is worth noting that including the cultural context in climate education targeting this generation is crucial for its effectiveness. The attitudes of young people towards climate change depend not only on knowledge, but also on the values they profess, which are shaped at a young age. Both international and Polish studies show that these attitudes vary depending on the level of individualism and collectivism (Nowak et al., 2023). Research conducted by Grapsas shows that the level of scepticism towards climate change among young people (aged 12-14) from the Netherlands, China and Colombia is associated with a preference for individualistic values, especially self-improvement, over the well-being of the community (Grapsas et al., 2023).

In terms of Polish research, on the one hand, Blachnicka-Ciacek distinguished three types of attitudes of young adults (aged 18-30) towards climate change: concerned, confused and doubtful (Blachnicka-Ciacek, 2020). On the other hand, research conducted among Gen Z respondents by Hadaś and Broda showed that very few respondents are able to correctly define the concept of sustainable development, which indicates low awareness of the topic, despite it being a common and well-known trend, especially among young people. The authors state that it is necessary to bolster

the ecological awareness of Gen Z, which may result in more pro-ecological consumer choices in the future (Hadaś & Broda, 2025).

Currently, in the opinion of the authors of the study, this topic has not been fully examined in terms of Gen Z's preferences for choosing a more ecological delivery option and what message appearing when choosing a delivery option could convince them to make conscious, ecological decisions. Last-mile delivery (LMD) is part of the broader concept of last-mile logistics (LML), which refers not only to the last part of the route itself but also to route planning and efficient delivery sequencing, as well as taking into account delivery time constraints and possible obstacles encountered along the way (Al-Rahamneh et al., 2025). This became the basis for conducting this study. It uses the definition of "last-mile delivery in e-commerce" proposed by the authors: *The concept of last mile in e-commerce refers to the last section of the route that a delivery to a customer must cover after making a purchase. This delivery can be made directly to the customer's address (courier), to a store (self-collection option) or to a parcel machine.*

Research methods

Idea of the research, sample, data collection and the characteristics of respondents

In the research procedure, the goal was adopted, the problem formulated, the research question asked, and then the research tools were adjusted. The authors decided to combine a literature review and online survey questionnaires; literature and comparative studies were also used, as well as a quantitative research method (CAWI survey, original questionnaire created by the authors). In order to obtain a complete picture of the issue in question, it was decided to adopt a comprehensive approach to the problem, which included two main stages, as described in Figure 2.

Structure of the stages of research

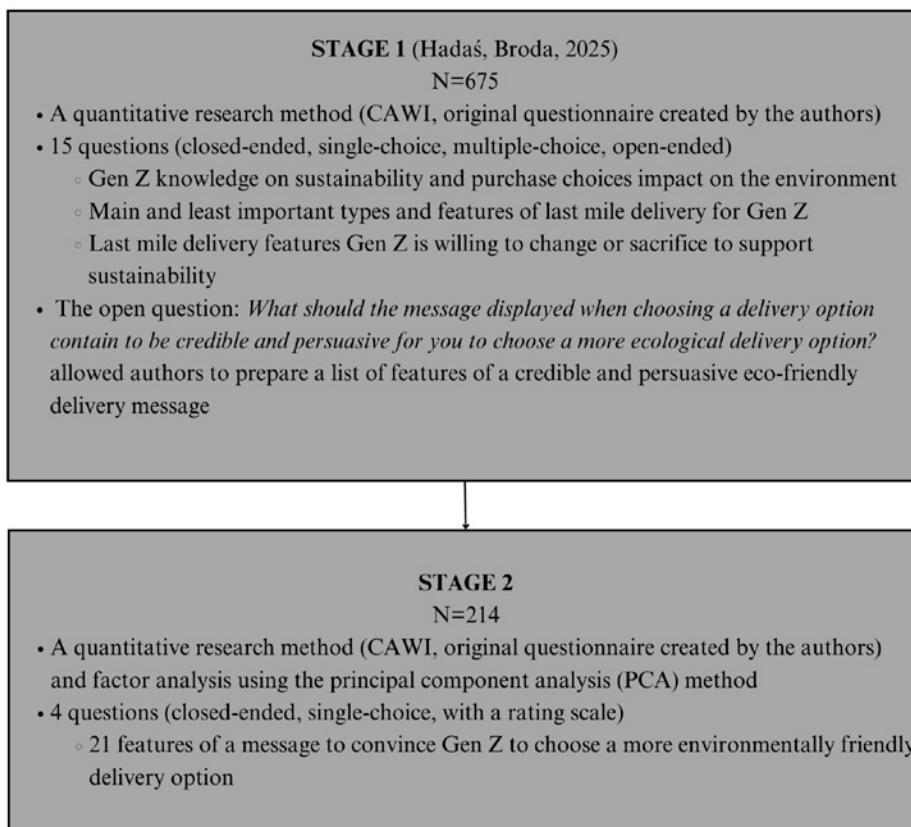


Figure 2. Structure of the stages of research

Stage 1 involves a quantitative research method using a CAWI survey to assess Gen Z's knowledge of sustainability, basic information about the types of goods that consumers' purchase and delivery models, and how their purchase choices impact the environment (Hadaś & Broda, 2025). This allowed identification of the most and least important last-mile delivery features for this particular generation, and explores which features they are willing to change or sacrifice to support sustainability. In the second stage of the research, by analyzing the respondents' answers to the open question: "What should the message displayed when choosing a delivery option contain to be credible and persuasive for you to choose a more ecological delivery option?", the authors proposed a list of features of the message that will be credible and persuasive to choose a more ecological delivery option.

Therefore, Stage 2 builds on the findings of Stage 1, employing another CAWI survey and factor analysis to identify the features of a persuasive message that could convince Gen Z to choose more environmentally friendly delivery options.

The survey form from Stage 2 was divided into three main parts. The first part relied on questions related to respondents' opinions on the environmental impact of purchasing choices regarding last-mile delivery. The next part comprised questions regarding the assessment of the extent to which the message features proposed by the study authors would be credible and convincing in choosing a more ecological delivery option. Consequently, the respondent would be willing to choose a longer waiting time for the shipment, knowing that the decision would have a significant, positive impact on the environment. The last part concerned questions relating to the demographic and social affiliation of the respondents.

The authors defined the following requirements for selecting the research sample, and the group of respondents includes people who met all the following compulsory criteria:

- The respondent is a representative of Generation Z (i.e. over 18 years old and under 30 years old).
- The respondent regularly does online purchasing.

This is a confirmation that the respondents have a set of features directly related to the topic of the study. The invitation to participate in the study was sent to the respondents directly by the authors. In order to examine the respondents as efficiently as possible, the survey method was used (an original questionnaire was prepared in a Google Form). Because social media platforms represent primary communication channels for Gen Z, it was decided that the survey was conducted in an anonymous form on the social media platforms (Facebook, LinkedIn) and in online closed student groups, in which a link to the Google questionnaire was provided.

Table 1. The characteristics of respondents

Respondents	N = 214	
Gender	male	N=116
	female	N=98
Age	18-25	N=187
	26-30	N=27
Occupation	Unemployed student	N=77
	Unemployed	N=2
	Working student	N=109
	Working	N=26
Place of residence	Village	N=53
	City up to 50k inhabitants	N=28
	City from 50k to 150k inhabitants	N=17
	City from 150k to 500k inhabitants	N=23
	City over 500k inhabitants	N=93

(N=212).

The research was conducted from December 2024 to March 2025. According to the Central Statistical Office (CSO), in 2024 there were 4 497 925 people born in Poland between 1995 and 2006. The required research sample was indicated using the following formula for the minimum sample size for a known population size (Halik, 2002). The minimum sample size (N_{min}) for a standard value for a given significance level of $Z=1.96$ and an assumed estimation error of $d=10\%$ is 96 people. 214 correctly completed questionnaires were received from individuals who met all the requirements. More than double the minimum required size rendered the study more credible. The characteristics of respondents who met all compulsory criteria are presented in Table 1.

The majority of the surveyed group were men (54.21%). The answers were provided mainly by respondents aged 18-25 (87.38%), working students (50.93%), and living in cities with more than 500,000 inhabitants (43.46%).

Results of the research

In the original survey questionnaire, respondents answered closed questions:

Q1: Does the respondent feel that their purchasing choices regarding last-mile delivery can have a real impact on the environment?

Q2: How does the respondent assess the extent to which the features of the message proposed by the authors are a credible and persuasive eco-friendly message to choose a more ecological delivery option?

The respondents made an assessment on a scale of 1-5, where 1 meant a low level and 5 – a high level. The proposed 21 message features are presented in Table 2.

Q3: Does the respondent feel that after reading the message containing the features from Q2, their purchasing choices regarding last-mile delivery may have a real impact on the natural environment?

Q4: After reading a message containing the features the respondent rated highest from Q2, would the respondent be willing to choose a longer waiting time for delivery, knowing that this decision would have a significant, positive impact on the environment?

The analysis of proposed features of the message shows that the number of people who believe their purchasing decisions have a small impact on the environment increased from 51.4% to 57.5%, and slightly more people recognised a significant impact, from 23.8% to 28%. The number of people who feel their decisions have no impact decreased (from 24.8% to 14.5%). This suggests that the message may have effectively increased environmental awareness (answers the research questions: RQ1, RQ3).

In the context of Q2, in order to reduce the number of variables and identify key features of a message for respondents to choose a more ecological delivery option, a statistical analysis (factor analysis) was conducted. Factor analysis was conducted using the principal component analysis (PCA) method with simple oblimin rotation, because it was assumed that there were correlations between variables. The results are presented in Table 2, with the factor loading values used for further analyses marked in red.

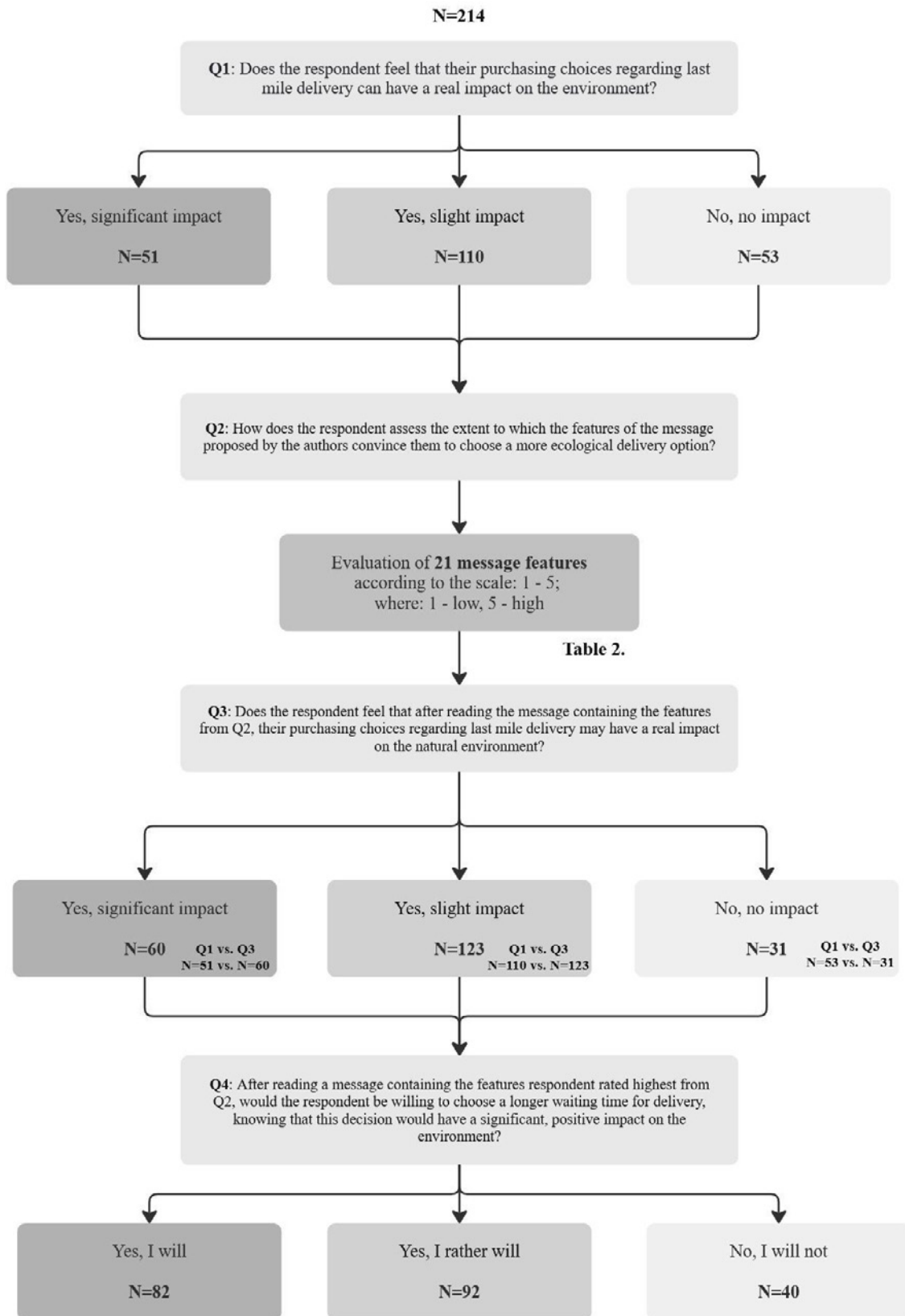


Figure 3. Structure of the questions and answers from the study (N=214).

Table 2. Values of factor loadings of features of credible and persuasive eco-friendly delivery message

Variable	Factor (1)	Factor (2)
The message is written in green font.	0.718	0.114
The message is written in a distinctive font.	0.657	0.150
The message contains numerical data regarding the impact of this delivery option on the natural environment.	0.273	0.590
The message contains information on how many people have used this delivery option so far.	0.400	0.317
The message contains information on the carbon footprint generated by the specifically selected delivery option.	0.173	0.727
The message contains information on the carbon footprint generated by each type of delivery option offered.	0.141	0.814
The message contains brief information on the % reduction in CO2 emissions compared to the standard delivery option.	0.165	0.738
The message contains information on the amount of CO2, SO2, Nox, PM10, PM2.5 emissions generated by this delivery option.	0.093	0.773
The message explains why the selected delivery option allows you to reduce your carbon footprint.	0.344	0.620
The message contains a link to additional materials (including scientific articles, reports) on the impact of your choice of delivery option on the natural environment.	0.042	0.628
The message contains a link to the company's marketing materials (e.g. regarding the company's participation in ecological campaigns).	0.201	0.511
The message contains a link to information on the calculation method used by the company to determine the impact of deliveries on the environment.	0.014	0.642
The message contains an example or an apt comparison.	0.532	0.312
The message contains a comparison of the impact of each type of delivery on the natural environment.	0.396	0.616
The message contains the phrase „You are eco by choosing this delivery!“ or „You care about the environment by choosing this delivery!“ or „By choosing this delivery, you support the environment!“.	0.787	0.085
The message contains a thank you for choosing an eco-friendly delivery option.	0.814	0.094
The message contains a symbol indicating that this delivery option is „ecological“.	0.808	0.204
The message contains a „green leaf“ symbol.	0.834	0.173
The message contains three „green leaf“ symbols along with an indication of how „eco“ the specific delivery option is (the number of filled „green leaf“ contours).	0.758	0.255
The content of the message fits in one line.	0.636	0.048
The message about the potentially positive impact on the environment of a specific delivery option is short, there is a „show more“ button.	0.553	0.290
Variance	5.783	4.987
Participation	0.275	0.237

Source: authors' work (N = 214) using Statistica Soft 13.1.

To improve readability and obtain a simple factor structure, the factor loading matrix was subjected to varimax rotation. This increased the interpretability of the factors by sharpening the factor loadings. After rotation, each factor better reflected a specific set of variables, which facilitated their interpretation. Ten variables had high factor loadings (above 0.7) on at least one identified factor. Thus, the analysis indicates strong relationships between variables and factors (answer the research question: RQ2). Variables with lower loadings were excluded from further analysis.

Discussion/Limitation and future research

As a result of the analysis, the following results were obtained for the two main groups of factors of features of a message dedicated to Gen Z, which is to encourage the choice of a more ecological delivery option. It is shown in Figure 4.

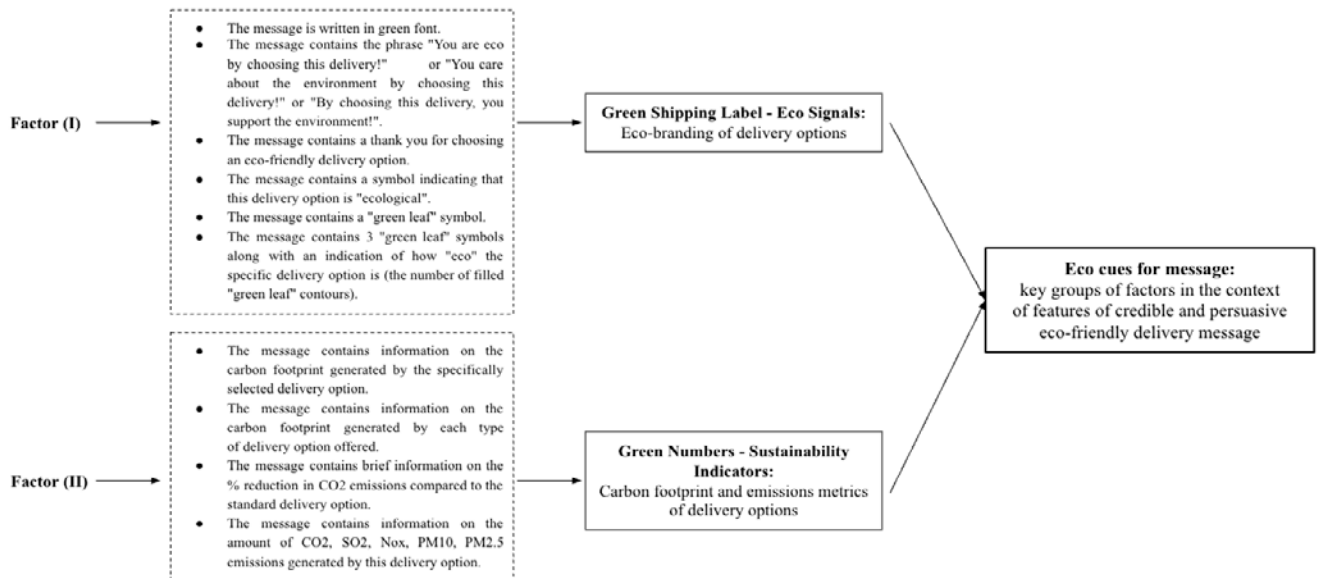


Figure 4. Key groups of factors in the context of features of a credible and persuasive eco-friendly delivery message

Figure 4 shows two categories of factors: Green Shipping Label – Eco Signals: Eco-branding of delivery options, and Green Numbers – Sustainability Indicators: Carbon Footprint and Emissions Metrics of delivery options. The first category indicates the visual and emotional aspects of the message, with particular emphasis on the green font colour. The second category describes hard numerical data, carbon footprint and emission metrics. In the assessment of Gen Z, the message plays a persuasive and numerical role in accordance with the features selected in the study.

When preparing an appropriate message, the greenwashing aspect should be taken into account. This term consists of a combination of the words "green", as in 'green' associated with ecology, and "whitewash", which in the context of ecology can mean covering up information, manipulation, or deliberately misleading (Kabaja et al., 2023). The risk of greenwashing is particularly high due to the lack of uniform standards and classification of ESG (Environmental, Social and Governance) data, which prevents reliable measurement and comparability between different companies (Malec, 2024). This procedure can, unfortunately, be used to convince customers to choose a delivery option with a message suggesting that it is environmentally friendly. According to the authors, this is why eco-responsibility is crucial in this aspect, as is designing the message in an honest way, where the information is confirmed by particular data, reports, and analyses. What is more, this constitutes something of a challenge, in view of the current eco trends and Gen Z preferences.

Moreover, in reference to the use of AI to analyse customer preferences and behaviour to promote eco-friendly delivery options by Generation Z, it should be noted that AI enables businesses to analyse large data sets in order to better understand customer preferences and offer personalised recommendations and promotions (Nadda et al., 2024). AI technologies such as machine learning, natural language processing, and predictive analytics are redefining customer interactions, providing more effective and satisfying experiences (Whig et al., 2024). Next, AI can support the promotion of sustainable products through recommendations based on users' purchase history, behaviour, and demographics (Pradhan et al., 2023).

Among the limitations of the online survey questionnaire, particularly in online surveys, is the fact that respondents with strong opinions or specific characteristics may be more likely to

participate, leading to a non-representative sample (Andrade, 2020). Increasing numbers of users also expect personalised experiences during e-commerce purchasing and better tailoring of the content displayed to their individual preferences. In recent years, AI has begun to provide a robust response to these needs, playing a key role in improving user experience and shaping their behaviours. With AI-based personalisation using advanced algorithms and machine learning techniques, it is possible to customise content and product recommendations for the most tailored buyer experience (Raji et al., 2024). Just as AI can be a useful tool for directing consumers toward convenient decisions based on their preferences, it can also be helpful in terms of moderating buyers' choices about delivery methods and guiding them toward choosing more environmentally friendly deliveries. AI with access to customer preference data could analyse which messages (length, form, content) will potentially influence customers to push them toward choosing more sustainable delivery and show personalised messages at the stage of finalising delivery. Thanks to this, AI can be used not only to boost sales performance but also to support sustainability (Nishant et al., 2020).

According to the authors of the study, AI will soon certainly be used to support and personalise messages regarding ecological delivery options, providing personalised recommendations in the context of sustainable development. Based on historical data on the choices of delivery options from different customer segments, AI tools could generate such a message (containing specific features, indicated and previously selected by the customer) that would convince the user to choose a more ecological delivery option. According to the authors, an additional question during the user registration in the online store would be helpful for registered users, thanks to which the AI would be able to suggest an appropriate message (answer the research question: RQ4). This is certainly a topic for further research. What is more, the problem of population description also occurs, as online surveys can suffer from the inability to describe the population to which they are distributed. In this case, precisely determining the birth rate of Gen Z made it difficult to generalise findings (Andrade, 2020). In summary, in order for the proposed message to be effective and to encourage the choice of an ecological delivery option, AI will be an invaluable support in its personalisation and adaptation of the message to the preferences of a specific user. The indicated factors (Figure 4) suggested in this paper will provide an effective tool for this purpose.

Conclusions

In conclusion, this study provides a comprehensive view of preferences and environmental awareness in last-mile delivery in the context of preferences of Generation Z and indicates the importance of using AI to support customisation and personalisation of generated messages regarding choosing an eco-friendly delivery option. Thus, the main goal of the study, which was to present the features of a credible and persuasive eco-friendly delivery message in the context of the idea of sustainable development for Gen Z, was achieved.

Based on the study, it should be stated that there are two significant groups of communication factors that have a real impact on changing the purchasing decision regarding the selection of the last mile delivery option by Gen Z. These groups are: Green Shipping Label – Eco Signals: Eco-branding of delivery options and Green Numbers – Sustainability Indicators: Carbon Footprint and Emissions Metrics of delivery options. The first category of factors focuses on the visual and emotional aspects of the message, while the second category includes substantive content and specific data. By seeking the optimal mix of both categories of factors, a “model” message can be proposed (Table 3), which indicates the scope of AI support for analysing its effectiveness and improvement.

Further verification studies to improve the message can be based on the use of AI tools for data analysis. AI support in the analysis of customer choice statistics in specific cases should:

- enable verification of the effectiveness of recommended messages (both “emotional” and “rational” and their mix),
- categorize customers,
- identify the relationship between the type of message and its effectiveness and the category of the product delivered and its characteristics (category of customers).

Table 3. A credible and persuasive eco-friendly delivery message is recommended to Generation Z consumers. The structure of the message and the scope of AI support for analysing its effectiveness and improvement

Main categories of factors	Eco-branding of delivery options			Carbon Footprint and Emissions Metrics of delivery options		
Nature of the message	"emotional"			"rational"		
Type of components /features of the message	pictograms /symbols	font	emotional message	carbon footprint data	CO ₂ reduction % data	emissions of particular substances
Examples	trees, green leaf	green	<i>You are eco-friendly!</i>	<i>-18% compared to standard delivery</i>	<i>15% reduction in CO₂ emissions</i>	<i>0.35 kg of CO₂ per package</i>
Example of message	<i>Thank you! By choosing this delivery option, you are eco-friendly! (green font), (three green leaves)</i>			<i>By choosing this delivery option, you reduce your emissions by approximately 0.6 kg of CO₂, up to 0.4 kg of CO₂ per parcel.</i>		
Scope of AI support	Analysis of the relationship between the type of message and its effectiveness and the category of the product delivered and the characteristics of the customers (customer category).					
Nature of the message	Mix of "emotional" and "rational"					
Example of message	<i>By choosing this delivery option, you're making an eco-friendly choice! You help reduce emissions by up to 1.2 kg of CO₂, or 0.9 kg per parcel (green tree).</i>					
Scope of AI support	Analysis of the relationship between the message mix (emotional and rational content) of the message and its effectiveness, and the category of the product delivered and the characteristics of customers (customer category).					

In-depth data analysis should finally allow for adapting the structure of the message to the characteristics of the customer category and the category of products purchased. As a result, an AI model should be developed to generate personalised messages tailored to specific customer segments. However, the implementation of AI in the process seems to be of key importance. Moreover, it can certainly be stated that this is an aspect for further consideration and, as a result, a message can be developed with the assigned specific features for a specific customer.

This research not only highlights the critical role of the discussed issue and the importance of eco-awareness when making purchasing decisions and choosing delivery options among Gen Z, but also the significance of the problem, and indicates directions for further research in this area with the use and support of AI. According to the authors of the study, in view of the growing environmental pressures on urban delivery systems and changing consumer expectations regarding sustainable service provision, it would be necessary to popularise this concept, as a research gap currently exists on this topic.

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The contribution of the authors

Conceptualisation, Ł.H., and Z.S.; literature review, Z.S. and M.B.; methodology, Ł.H., Z.S. and M.B.; formal analysis, Ł.H., and Z.S.; writing, Ł.H., Z.S. and M.B.; conclusions and discussion, Ł.H., Z.S. and M.B.

References

- Akrofi, M. M., Antwi, S. H., & Gumbo, J. R. (2019). Students in climate action: A study of some influential factors and implications of knowledge gaps in Africa. *Environments*, 6(12). <https://doi.org/10.3390/environments6020012>
- Al-Rahamneh, A., Serrano-Hernandez, A., & Faulin, J. (2025). The Impact of Integrating Open Data in Smart Last-Mile Logistics: The Example of Pamplona Open Data Catalog. *Sustainability*, 17(2), 408. <https://doi.org/10.3390/su17020408>
- Andrade, C. (2020). The limitations of online surveys. *Indian journal of psychological medicine*, 42(6), 575-576. <https://doi.org/10.1177/0253717620957496>
- Białokozowicz, A., & Ryciuk, U. (2022). Wykorzystanie autonomicznych robotów dostawczych w usługach kuryerskich ostatniej mili. *Akademia Zarządzania*, 6(3), 387-400. <https://doi.org/10.24427/az-2022-0048> (in Polish).
- Blachnicka-Ciacek, D. (2020). Młodzi Polacy wobec kryzysu klimatycznego. *Youth Working Papers*, (1). https://www.researchgate.net/publication/344076930_Mlodzi_Polacy_wobec_zmian_klimatycznych (in Polish).
- Bouhouras, E., Ftergioti, S., Russo, A., Basbas, S., Campisi, T., & Symeon, P. (2024). Unlocking the potential of pick-up points in last-mile delivery in relation to Gen Z: Case studies from Greece and Italy. *Applied Sciences*, 14(22), 10629. <https://doi.org/10.3390/app142210629>
- Boysen, N., Fedtke, S., & Schwerdfeger, S. (2021). Last-mile delivery concepts: A survey from an operational research perspective. *OR Spectrum*, 43(1), 1-58. <https://doi.org/10.1007/s00291-020-00607-8>
- Burkholder, K. C., Devereaux, J., Grady, C., Solitro, M., & Mooney, S. M. (2017). Longitudinal study of the impacts of a climate change curriculum on undergraduate student learning: Initial results. *Sustainability*, 9(6), 913. <https://doi.org/10.3390/su9060913>
- Chen, X., Guo, L., & Islam, Q. U. (2024). Revolutionizing e-commerce logistics: AI-driven path optimization for sustainable success. *International Journal of Information Technologies and Systems Approach (IJITSA)*, 17(1), 1-15. <https://www.igi-global.com/article/revolutionizing-e-commerce-logistics/355016>
- Comi, A., & Nuzzolo, A. (2016). Exploring the relationships between e-shopping attitudes and urban freight transport. *Transportation Research Procedia*, 12, 399-412. <https://doi.org/10.1016/j.trpro.2016.02.075>
- Dey, A., LaGuardia, P., & Srinivasan, M. (2011). Building sustainability in logistics operations: A research agenda. *Management Research Review*, 34(11), 1237-1259. <https://doi.org/10.1108/01409171111178774>
- Fozooni, A., Nazari, S., & Jamalpur, A. (2024). Prioritizing big data applications in e-commerce considering sustainable development indicators. *Journal of Future Sustainability*, 4(3), 169-178. <https://doi.org/10.5267/jfs.2024.9.002>
- Główny Urząd Statystyczny. (2021). *Polska w liczbach 2021*. <https://stat.gov.pl/obszary-tematyczne/inne-opracowania/inne-opracowania-zbiorcze/polska-w-liczbach-2021,14,14.html> (in Polish)
- Grabiwoda, B. (2019). *E-konsumenci jutra. Pokolenie Z i technologie mobilne*. Łódź: Wydawnictwo Nieoczywiste. (in Polish)
- Grapsas, S., Becht, A. I., & Thomaes, S. (2023). Self-focused value profiles relate to climate change skepticism in young adolescents. *Journal of Environmental Psychology*, 87, 101978. <https://doi.org/10.1016/j.jenvp.2023.101978>
- Halik, J. (2002). *Metodyka pisania pracy magisterskiej i studyjnej*. Warszawa: AON. (in Polish)
- Hadaś, Ł., & Broda, M. (2025). Preferences of Generation Z in terms of readiness for changes in last-mile delivery in the context of sustainability. In R. Marczewska-Kuzma, Ł. Hadas, & P. Golinska (Eds.), *Implementation of circular economy in supply chains and production systems* (pp.149-160). Cham: Springer. <https://doi.org/10.1007/978-3-031-88926-4>
- Kabaja, B., Wojnarowska, M., Ćwiklicki, M., Buffagni, S., & Varese, E. (2023). Does environmental labelling still matter? Generation Z's purchasing decisions. *Sustainability*, 15(18), 13751. <https://doi.org/10.3390/su151813751>
- Kozłowski, W., & Rutkowska, A. (2016). Konsumpcjonizm a marketing społecznie zaangażowany. In J. Ejdyś (Eds.), *Społeczna odpowiedzialność i zrównoważony rozwój w naukach o zarządzaniu: aspekty teoretyczne i aplikacyjne* (s. 235-251). Toruń: Dom Organizatora, TNOiK. (in Polish)
- Krzyżanowska, K., Parzonko, A., & Sieczko, A. (2024). Oczekiwania konsumentów pokolenia Z dotyczące zakupów produktów spożywczych prosto od rolnika. *Turystyka i Rozwój Regionalny*, 21, 93-102. <https://doi.org/10.22630/TIRR.2024.21.8> (in Polish)
- Mahajan, N., Singh, V., Kaur, N., & Hakeem, O. T. (2024). Sustainability through transformative technologies: Green banking and SDG-13. In T. Singh, R. Goel, & J.A. Sotto (Eds.), *Sustainable technology for society 5.0* (pp. 86-101). CRC Press. <https://doi.org/10.1201/9781003365525>
- Malec, A. (2024). Zjawisko greenwashingu a decyzje zakupowe pokolenia Z. In D. Teneta (Eds.), *Zrównoważony rozwój – trendy, wyzwania, kontrowersje* (s. 91-109). Wrocław: Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu. (in Polish)
- Nadda, V., Tyagi, P. K., Singh, A., & Singh, V. (2024). *AI Innovations in Service and Tourism Marketing*. IGI Global.

- Nishant, R., Kennedy, M., & Corbett, J. (2020). Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda. *International Journal of Information Management*, 53, 102104. <https://doi.org/10.1016/j.ijinfomgt.2020.102104>
- Nozari, H. (2024). Supply chain 6.0 and moving towards hyper-intelligent processes. In H. Nozari (Ed.), *Information logistics for organizational empowerment and effective supply chain management* (pp. 1–13). IGI Global. <https://doi.org/10.4018/979-8-3693-0159-3.ch001>
- Nozari, H., Fallah, M., & Szmelter-Jarosz, A. (2021). A conceptual framework of green smart IoT-based supply chain management. *International Journal of Research in Industrial Engineering*, 10(1), 22–34. https://www.researchgate.net/publication/349605408_A_Conceptual_Framework_of_Green_Smart_IoT-based_Supply_Chain_Management
- Nowak, K. A., Durczak, K., & Bartkowiak, M. (2023). Postawy reprezentantów pokolenia Z wobec wyzwań klimatycznych w kontekście Modelu Ograniczeń Planety. *Studia BAS*, 2(74), 233–259. <https://doi.org/10.31268/StudiaBAS.2023.20> (in Polish).
- OECD. (2020). *The impact of e-commerce on urban logistics*. Paris: OECD Publishing.
- Paczka, E. (2020). Zmiana zachowań rynkowych pokolenia Z. *Ekonomia – Wrocław Economic Review*, 26(1), 21–34. <https://doi.org/10.19195/2658-1310.26.1.2> (in Polish)
- Pradhan, A., Ghosh, A., Mondal, R., Saxena, K. A., Dutta, P. K., & Mitra, A. (2023). E-commerce recommendation engine for sustainable products. 7th IET Smart Cities Symposium, SCS 2023, Virtual, online. IET Conference Proceedings, 2023(44), 77–83.
- Ragin-Skorecka, K., Grobelna, K., & Nowak, F. (2024). Identifying e-commerce processes is key to sustainable automation using AI. *European Research Studies Journal*, 27(A), 621–633. <https://doi.org/10.35808/ersj/3740>
- Raji, M. A., Olodo, H. B., Oke, T. T., Addy, W. A., Ofodile, O. C., & Oyewole, A. T. (2024). E-commerce and consumer behavior: A review of AI-powered personalization and market trends. *GSC Advanced Research and Reviews*, 18(3), 066–077. <https://doi.org/10.30574/gscarr.2024.18.3.0090>
- Iron Mountain. (2021). *Raport: Why the COVID-driven acceleration in digitising business processes could be short-lived*. <https://resources.ironmountain.com/en-gb/whitepapers/c/ctrl-alt-repeat-why-the-covid-driven-acceleration-in-digitising-business>
- Ridwan, N. H., Musa, C. I., & Haeruddin, M. I. M. (2025). Decision-making behavior of generation Z in online purchases: A systematic literature review. *Multidisciplinary Reviews*, 8(12), 2025384. <https://doi.org/10.31893/multirev.2025384>
- The Central Statistical Office (CSO) from 26/08/2025 *Age pyramid of the Polish population since 1970 (with forecast)*. <https://stat.gov.pl/obszary-tematyczne/ludnosc/ludnosc/ludnosc-piramida/> (in Polish).
- Whig, P., Bhatia, A. B., & Yathiraju, N. (2024). AI-driven innovations in service marketing transforming customer engagement and experience. In *AI Innovations in Service and Tourism Marketing* (pp. 17–34).
- Zaborowski, H., & Antonowicz, M. (2023). Bezpapierowe łańcuchy dostaw – rola i znaczenie. *Economics and Organization of Logistics*, 8(2), 121–141. <https://doi.org/10.22630/EIOL.2023.8.2.16> (in Polish).

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ŚWIADOMOŚĆ EKOLOGICZNA GENERACJI Z: WIARYGODNY I PRZEKONUJĄCY KOMUNIKAT O EKOLOGICZNEJ DOSTAWIE W OSTATNIEJ MILI, WSPARTY PRZEZ AI

STRESZCZENIE: Dostawa ostatniej mili to najbardziej złożony i kosztowny etap łańcucha dostaw, na którym kwestie zrównoważonego rozwoju zyskują strategiczne znaczenie. Ekologiczne rozwiązania logistyczne są coraz bardziej cenione, szczególnie przez Pokolenie Z, osoby wychowane w erze cyfrowej, aktywnie dokonujące zakupów online i niezwykle wrażliwe na kwestie środowiskowe. Sztuczna inteligencja (AI) wspiera ten proces, analizując zachowania konsumentów i skuteczność przekazów, umożliwiając spersonalizowaną komunikację. Celem artykułu jest przedstawienie cech wiarygodnego i przekonującego ekologicznego przekazu dostawczego w kontekście idei zrównoważonego rozwoju w ocenie Pokolenia Z. Wyniki wskazują, że dwa typy przekazów mają największy wpływ: Sygnały Ekologiczne (symbole, kolory, język emocjonalny) oraz Wskaźniki Zrównoważonego Rozwoju (dane dotyczące śladu węglowego, wskaźniki redukcji CO₂). Najskuteczniejsze przekazy łączą oba te elementy. Autorzy sugerują przykładowy przekaz – jego strukturę i zakres wsparcia AI w celu analizy jego skuteczności i poprawy. Badanie potwierdza znaczenie spersonalizowanej komunikacji dla Pokolenia Z i podkreśla potrzebę dalszych badań w tym obszarze.

SŁOWA KLUCZOWE: pokolenie Z, dostawa ostatniej mili, zrównoważony rozwój, ekologiczne opcje dostaw z wykorzystaniem AI