# EXPLORING SAFETY CONCERNS, PRIVACY ISSUES AND ENVIRONMENTAL IMPACT ON CONSUMER ACCEPTANCE OF DRONE DELIVERY

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**Abstract.** This study explores the factors influencing consumer acceptance of drone delivery services in Penang, Malaysia, focusing on safety concerns, privacy issues, and environmental impact. Using the Theory of Planned Behaviour (TPB) as the theoretical framework, a quantitative analysis was conducted based on responses from 400 participants. Reliability tests, normality tests, descriptive statistics, Pearson correlation, and multiple regression analysis were employed to analyze the data. The results indicate that all three factors significantly impact consumer acceptance, with environmental impacts having the highest influence, followed by safety concerns and privacy issues. These findings highlight the importance of robust safety protocols, transparent privacy measures, and promoting the environmental benefits of drone delivery to enhance consumer trust and acceptance. The study contributes by integrating contemporary factors relevant to consumer acceptance and providing practical recommendations for service providers and policymakers to foster this acceptance. Future research should include additional factors and consider comparative studies to further understand the dynamics of consumer acceptance of drone delivery services.
**Keywords**: *drone delivery, safety concerns, privacy issues, environmental impacts, consumer acceptance*

## Introduction

In Malaysia, the last-mile delivery sector faces significant challenges due to the country's diverse geographical landscape and rapidly growing e-commerce market. Traditional delivery methods are struggling to meet increasing consumer demands, leading to inefficiencies, delays, and environmental concerns. Urban areas, in particular, face congestion issues, narrow streets, and limited parking, which exacerbate these problems and increase operational costs for businesses while contributing to pollution and carbon emissions (Akter et al., 2023; Freudendal-Pedersen, 2020). Drone delivery has emerged as a promising solution to address these challenges by potentially offering faster, more efficient, and environmentally friendly last-mile delivery options. However, consumer acceptance of drone delivery is influenced by various factors, including safety concerns, privacy issues, and environmental impact (Prakash et al., 2022). Ensuring the safe operation of drones in densely populated areas and near other aircraft is a significant concern, as drone-related accidents and near-misses have raised alarms about the potential risks of widespread drone deployment. Additionally, privacy concerns, particularly regarding the use of drones for surveillance, require careful regulatory balancing to address public apprehension. Despite the environmental benefits of drone delivery, including reduced carbon emissions, consumer concerns about the ecological impact of drones persist (Yoo et al., 2018).

In Malaysia, the acceptance of drone deliveries remains uncertain due to safety, privacy, and environmental concerns. There is a notable lack of empirical research and practical implementation of drone delivery systems in the Malaysia context, making it difficult for businesses to evaluate the feasibility and effectiveness of this technology for optimizing last-mile delivery services. This study aims to fill this gap by investigating the key factors influencing consumer acceptance of drone delivery in Malaysia and providing insights into how these factors can be managed to enhance adoption. The research objectives are to determine the relationships between safety concerns, privacy issues, environmental impact, and consumer acceptance of drone delivery in Malaysia. By addressing these objectives, this study aims to provide valuable empirical insights and recommendations that can facilitate the successful implementation of drone delivery services. This, in turn, can contribute to a more efficient and sustainable last-mile delivery system in Malaysia, benefiting consumers, businesses, and policymakers alike.

### *Literature review*

The last-mile delivery segment of the logistics industry has received increased attention in recent years due to its essential role in offering the timely and effective delivery of goods to end consumers. With the rising popularity of e-commerce and evolving consumer demands, there is a greater demand for faster, more convenient delivery options, encouraging businesses to look into innovative last-mile logistics solutions. Drone deliveries are one such alternative that has gained attention in recent years. This literature review aims to give a complete overview of existing studies on drone delivery, with an emphasis on its implications for last-mile services, customer acceptance, and regulatory issues.

### *Consumer acceptance on drone delivery*

Consumer acceptance plays a pivotal role in the widespread adoption of drone delivery systems. While drones offer faster delivery times and more convenience, consumer perceptions towards this developing technology are influenced by a variety of factors, including safety concerns, privacy issues, and environmental concerns (Hassan, 2024). According to research, customers are mostly open to the idea of drone delivery but are concerned about safety issues, potential privacy violations, and the environmental impact of drone operations. Understanding these concerns is crucial for companies and legislators seeking to increase the acceptance and adoption of drone delivery services. According to an Associated Press poll, only 21% of respondents supported commercial drone technology, 43% opposed commercial drones, and 35% were indecisive (Guillot and Pouget, 2015). Ramadan et al. (2017) stated that consumer opinions of drone delivery are heavily influenced by its practical benefits, technological quality, and perceived risks. Based on the Theory of Planned Behaviour (TPB) proposed by Ajzen (1991), customers are more likely to accept technological innovation when they perceive its benefits to outweigh its drawbacks (Ramadan et al., 2017). As a result, it is logical to assume that if public safety programmes are able to prove people's faith in the organisation, it will be easier to support drone acceptance. Although drone technology is a revolutionary business tool, particularly in the e-commerce and logistics industries, consumers have begun to worry about the many risks related to it. This study focuses on existing 'potential harm' that may have a direct impact on customers'

decisions to use drone-based distribution. According to Farber (2016), privacy, security, and safety are major concerns about commercial drone technology.

### *Safety concern*

The operation of drone delivery systems requires the highest level of safety. Drone flights may pose dangers such as mid-air collisions, take-off and landing accidents, and interference with manned aircraft (Merkert and Bushell, 2020). Regulatory agencies and industry stakeholders are actively striving to reduce these risks by creating safety standards, airspace management protocols, and collision avoidance technologies (Hussein et al., 2020). Despite these efforts, public perception of drone safety remains a major obstacle to its acceptance and adoption. If a drone damages buildings or personal property while delivering products to a customer, consumers may be held accountable for the unanticipated incident. In addition, the safety issues involve the package's condition and safety. Consumers expect to receive their packages in good shape, and if the product is damaged, the customer will make assumptions about the potential drawbacks of this technology. Technological constraints associated with drone technology, such as a lack of safety features, result in a risk for people and property, providing a risk to public safety, whether with or without intent (Clarke and Moses, 2014). According to Ravich (2015), news articles about drone malfunctions are frequently reported around the world. These issues have increased the fears of legislators and residents alike, who see their lives compromised by the drone technology that surrounds them. For instance, Grubb (2014) reported that, while filming for an Australian triathlon, a drone accidentally injured an athlete's head.

### *Privacy issues*

Privacy concerns are another key issue influencing customer views concerning drone delivery. Drones with cameras and sensors raise concerns about the possibility of unauthorised surveillance, data collection, and violation of persons' privacy rights (Mekdad et al., 2023). Building consumer trust and confidence requires transparency, accountability, and compliance with data protection standards. Implementing privacy-enhancing technology and establishing strong data governance structures can help address these concerns and mitigate customer concerns. According to Ramadan et al. (2017), privacy is a major concern for average consumers. This is because drones are capable of violating an entity's privacy and acquiring confidential personal data. According to Farber (2016), businesses might use drones equipped with live video cameras to spy on and collect personal information about their customers. On top of that, Ravich (2015) stated that even in cases where commercial drone use is permitted, a drone's ability to legitimately enter people's personal spaces and collect a wide range of data ought to safeguard their right to privacy.

### *Environmental impact*

The environmental impact of drone delivery is another area of concern for customers and stakeholders. Drones have the potential to reduce carbon emissions and traffic congestion by refusing ground-based transportation routes, but their energy consumption, noise pollution, and carbon footprint must be properly managed. Assessing the entire environmental sustainability of drone operations involves a comprehensive assessment of elements such as energy efficiency, renewable energy

usage, and lifecycle emissions (Park et al. 2018). Promoting eco-friendly methods and implementing sustainability measurements into drone delivery operations can increase consumer trust and support. Stolaroff (2014) discovered that the vehicle's energy consumption is caused by the combustion of crude oil-refined diesel, which increases pollutants in the air. Trucks transporting goods for distribution travel far further than drone deliveries, which can fly on specified direct routes. Stolaroff et al. (2018) suggest using last-mile drones to reduce greenhouse gas emissions and energy use. They also provide regulatory guidelines for achieving environmental advantages, with a focus on warehouse needs.

## Materials and Methods

This research study is a descriptive study aimed at analyzing the relationships among variables that influence consumer acceptance of drone delivery in Penang, Malaysia. According to Penang Economic and Development Report 2019/2020, Penang is a rapidly developing urban area with a high rate of e-commerce activity. Therefore, this makes it an ideal location to examine consumer acceptance of drone delivery. The type of investigation is correlational, seeking to understand the associations between safety concerns, privacy issues, environmental impact, and consumer acceptance, as shown in *Figure 1*. The research employs a cross-sectional study design, with data gathered one time only. The target population for this study comprises consumers who use last-mile delivery services in Penang, Malaysia. A sample size of 400 respondents was determined using a simple random sampling technique to ensure a representative and unbiased sample. Data collection was conducted through surveys, which were distributed both physically and electronically using channels such as WhatsApp and Facebook to maximize participation and reach. The questionnaire for this study was adopted and adapted from various previous researchers to ensure suitability. It is divided into two sections: Section A for demographic information and Section B for variables influencing customer acceptance of drone delivery, such as safety concerns, privacy issues, and environmental impact. The demographic questions and safety concerns were adapted from Ayoubi (2019). Privacy issues were derived from Usmanova (2019), while the environmental impact was adapted from Mittendorf et al. (2017). Finally, the questions for the dependent variable, customer acceptance of drone delivery, were derived from Kamali (2018). The survey questionnaire included multiple-choice questions for demographic information and 5-point Likert-scale questions for assessing the variables. Content validity was conducted to determine the validity of the questionnaire by reviewing it with our expert, the supervisor. Furthermore, a pilot test was conducted with 30 respondents to refine the questionnaire and ensure its reliability. The unit of analysis in this study is the individual consumer who uses last-mile delivery services in Penang. Besides, data collection was facilitated through Google Forms, and the collected data were analyzed using SPSS software. This comprehensive approach ensures robust and reliable findings that contribute to understanding the key factors influencing consumer acceptance of drone delivery in Penang, Malaysia.

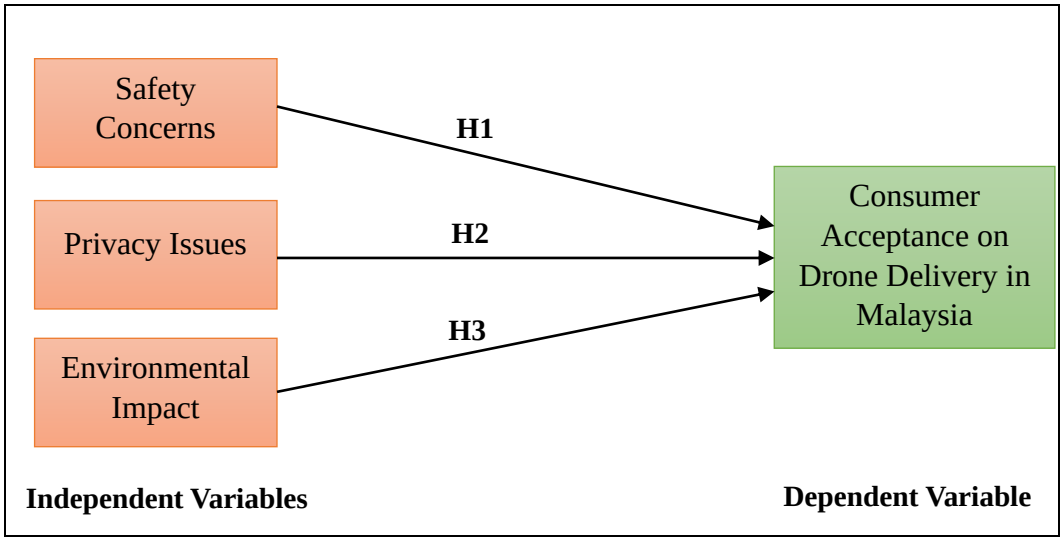


***Figure 1.*** *Research framework.*

## Results and Discussion

*Table 1* exhibits the value of Cronbach's alpha for all four variables. The reliability analysis shows that the measurement scales used in the survey are highly reliable. The Cronbach's alpha values for each variable indicate strong internal consistency: consumer acceptance (0.928), safety concern (1.000), privacy issues (0.729), and environmental impact (0.854). A Cronbach's alpha value above 0.7 is generally considered acceptable, indicating that the items within each scale are consistently measuring the intended construct. According to Sekaran and Bougie (2016), the exceptionally high value for safety concern (1.000) suggests excellent internal consistency. Overall, the high reliability of these scales supports their use in examining consumer acceptance of drone delivery services in Malaysia. *Table 2* exhibits the descriptive analysis used to describe the demographic background of respondents. The demographic profile of the respondents provides a comprehensive overview essential for understanding the context of the study on consumer acceptance of drone delivery services in Malaysia. The gender distribution is balanced, with 46% male and 54% female respondents, ensuring diverse perspectives. Age-wise, the majority are within the 26-35 age group (37.5%), followed by 18-25 (34%), 36-45 (18.3%), 46-55 (7.8%), and 56 and above (2.5%), indicating significant interest in drone delivery among younger generations. Professionally, 41.8% are employed, 31.3% are students, 19.3% are unemployed, and 7.8% are retired, reflecting varied economic activities. Online shopping frequency is high, with 51.5% shopping at least once a week, 26.5% 1-2 times per month, 15% 5-10 times per year, and 7% less often, suggesting familiarity with e-commerce. This diverse and engaged sample provides a robust basis for analyzing consumer acceptance of drone delivery services in Malaysia.

***Table 1****. Reliability test.*

| Variables | Items | Cronbach's Alpha value |
|---|---|---|
| Consumer acceptance | 4 | 0.928 |
| Safety concern | 4 | 1.000 |
| Privacy issues | 3 | 0.729 |
| Environmental impact | 5 | 0.854 |

***Table 2**. Demographic profile.*

| Variables | Frequency (N=400) | Percentage (%) |
|---|---|---|
| Gender | | |
| Male | 184 | 46% |
| Female | 216 | 54% |
| Age | | |
| 18-25 years | 136 | 34% |
| 26-35 years | 150 | 37.5% |
| 36-45 years | 73 | 18.3% |
| 46-55 years | 31 | 7.8% |
| 56 years and above | 10 | 2.5% |
| Profession | | |
| Student | 125 | 31.3% |
| Employed | 167 | 41.8% |
| Unemployed | 77 | 19.3% |
| Retired | 31 | 7.8% |
| Purchased Online | | |
| Yes | 400 | 100% |
| No | 0 | 0% |
| Often Buy | | |
| 1-2 times per month | 106 | 26.5% |
| 5-10 times per year | 60 | 15% |
| At least once a week | 206 | 51.5% |
| Less Often | 28 | 7% |
| Encourage Purchase | | |
| Yes | 296 | 74% |
| No | 65 | 16.3% |
| Maybe | 39 | 39% |

The Pearson's Correlation Analysis in *Table 3* reveals significant relationships between consumer acceptance of drone delivery (DV) and the three independent variables: safety concerns (IV1), privacy issues (IV2), and environmental impact (IV3). The correlation between consumer acceptance and safety concerns is $r=0.488$ ($p<0.001$), indicating a moderate positive relationship. As safety concerns are alleviated, consumer acceptance increases. The correlation between consumer acceptance and privacy issues is $r=0.465$ ($p<0.001$), also showing a moderate positive relationship; addressing privacy concerns boosts acceptance. Lastly, the correlation between consumer acceptance and environmental impact is $r=0.520$ ($p<0.001$), suggesting that positive perceptions of environmental benefits lead to higher acceptance. Overall, the analysis highlights that safety, privacy, and environmental factors significantly influence consumer acceptance of drone delivery services in Malaysia. According to Sekaran and Bougie (2016), regression analysis is used when researchers aim to predict the model on how much effect IV have on DV using the regression process of independent variables to the dependent variable (*Table 4*, *Table 5* and *Table 6*). The model summary in *Table 4* indicates that safety concerns, privacy issues, and environmental impacts collectively have a significant effect on consumer acceptance of drone delivery services in Malaysia. The R square value of 0.369 shows that 36.9% of the variance in consumer acceptance is explained by these factors. While the model accounts for a significant portion of the variance, other factors not included in this study may also play a role.

***Table 3***. *Correlation analysis.*

| Consumer acceptance (DV) | Safety concerns (IV1) | Privacy issues (IV2) | Environmental impact (IV 3) |
|---|---|---|---|
| Pearson Correlation | 0.488 | 0.465 | 0.520 |
| Sig. (2-tailed) | <.001 | <.001 | <.001 |
| N | 400 | 400 | 400 |

*Note: **Correlation is significant at the 0.01 level (2-tailed).*

***Table 4***. *Multiple regression analysis: Model summary.*

| Model Summary | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .608[a] | .369 | .364 | .40493 |

*Note: a. Predictors: (Constant), EI, SC, PI.*

***Table 5***. *Multiple regression analysis: Anova[a].*

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 37.996 | 3 | 12.665 | 77.242 | <.001[b] |
| | Residual | 64.932 | 396 | .164 | | |
| | Total | 102.927 | 399 | | | |

*Note: a. Dependent variable: CA. b. Predictors: (Constant), EI, SC, PI.*

***Table 6***. *Multiple regression analysis: Coefficient[a].*

| Model | | Unstandardized coefficients | | Standardized coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 1.157 | .208 | | 5.553 | <.001 |
| | SC | .248 | .047 | .262 | 5.271 | <.001 |
| | PI | .137 | .050 | .144 | 2.755 | .006 |
| | EI | .049 | .049 | .335 | 7.087 | <.001 |

*Note: a. Dependent variable: CA.*

The ANOVA in *Table 5* shows that the model examining the predictors of consumer acceptance (CA) of drone delivery services in Malaysia is statistically significant. With a p-value of less than 0.001, it indicates that safety concerns (SC), privacy issues (PI), and environmental impact (EI) significantly explain the variation in consumer acceptance. The high F-value further confirms that these independent variables collectively have a significant effect on consumer acceptance, highlighting their importance in understanding consumer acceptance of drone delivery. The coefficients table from the multiple regression analysis shows the influence of safety concerns (SC), privacy issues (PI), and environmental impact (EI) on consumer acceptance (CA) of drone delivery in Malaysia. Safety concerns (SC) have an unstandardized coefficient (B) of 0.248, indicating that each unit increase in safety concerns raises consumer acceptance by 0.248 units. This relationship is statistically significant ($t=5.271$, $p<0.001$), with a standardized coefficient (Beta) of 0.262, showing a moderate positive effect. Privacy issues (PI) have an unstandardized coefficient (B) of 0.137, suggesting a 0.137 unit increase in consumer acceptance per unit increase in privacy issues, which is also significant ($t=2.755$, $p=0.006$), with a Beta of 0.144, indicating a modest positive effect. Environmental impact (EI) has an unstandardized coefficient (B) of 0.049, indicating a 0.049 unit increase in consumer acceptance per unit increase in perceived positive environmental impact. This is highly significant ($t=7.087$, $p<0.001$) with a beta of 0.335, showing the strongest positive effect among the three variables. In summary, safety concerns, privacy issues, and environmental impact all significantly and positively influence consumer acceptance of drone delivery services in Malaysia, with environmental impact having the strongest effect.

H1: There is a significant relationship between safety concerns and consumer acceptance of drone delivery in Malaysia. The results, as depicted in *Table 6*, show a significant relationship between safety concerns and consumer acceptance of drone delivery ($p<0.001$). Thus, H1 is accepted.

H2: There is a significant relationship between privacy issues and consumer acceptance of drone delivery in Malaysia. The results, as depicted in *Table 6*, show a significant relationship between privacy issues and consumer acceptance of drone delivery ($p=0.006$). Thus, H2 is accepted.

H3: There is a significant relationship between environmental impact and consumer acceptance of drone delivery in Malaysia. The results, as depicted in *Table 6*, show a significant relationship between environmental impact and consumer acceptance of drone delivery ($p<0.001$). Thus, H3 is accepted.

## Conclusion

This study examined the factors influencing consumer acceptance of drone delivery services in Penang, Malaysia, focusing on safety concerns, privacy issues, and environmental impact. The findings revealed that all three factors significantly affect consumer acceptance, with the environmental impact showing the strongest influence. These insights underscore the importance of addressing safety and privacy concerns while highlighting the environmental benefits to enhance consumer acceptance. For businesses, understanding these factors can inform strategies to promote drone delivery services, ensuring they are safe, privacy-conscious, and environmentally friendly. For policymakers, the results highlight the need for comprehensive regulations that balance technological advancements with public concerns. Future research should explore additional factors influencing consumer acceptance and consider longitudinal studies to observe changes over time. Expanding the study to other regions of Malaysia or different countries could provide a broader understanding of consumer acceptance of drone delivery services globally. By addressing these factors, stakeholders can better navigate the challenges and opportunities of implementing drone delivery, ultimately contributing to a more efficient and sustainable last-mile delivery system.

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## Conflict of interest

The authors confirm that there is no conflict of interest involve with any parties in this research study.

## REFERENCES

[1] Ajzen, I. (1991): The theory of planned behavior. – Organizational Behavior and Human Decision Processes 50(2): 179-211.

[2] Akter, S., Hossain, M.A., Sajib, S., Sultana, S., Rahman, M., Vrontis, D., McCarthy, G. (2023): A framework for AI-powered service innovation capability: Review and agenda for future research. – Technovation 125: 17p.
[3] Ayoubi, F.O. (2019): Customers' perception of drone parcel delivery. – Varna University of Management 45p.
[4] Clarke, R., Moses, L.B. (2014): The regulation of civilian drones' impacts on public safety. – Computer Law & Security Review 30(3): 263-285.
[5] Farber, H.B. (2016): Keep out: The Efficacy of Trespass, Nuisance and Privacy Torts as Applied to Drones. – Georgia State University Law Review 33(2): 359-409.
[6] Freudendal-Pedersen, M. (2020): Sustainable urban futures from transportation and planning to networked urban mobilities. – Transportation Research Part D: Transport and Environment 82: 11p.
[7] Grubb, B. (2014): "River of blood" after drone "hits" Australian athlete. – Sydney Morning Herald 7: 1p.
[8] Guillot, B., Pouget, F. (2015): UAV application in coastal environment, example of the Oleron island for dunes and dikes survey. – In The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences 3: 6p.
[9] Hassan, M. (2024): Integration of UAVs in society: Opportunities and challenges from public viewpoint on UAVs in Civilian Airspace. – Haaga-Helia University of Applied Sciences 56p.
[10] Hussein, M., Nouacer, R., Ouhammou, Y., Villar, E., Corradi, F., Tieri, C., Castiñeira, R. (2020): Key enabling technologies for drones. – In 2020 23rd Euromicro Conference on Digital System Design (DSD), IEEE 8p.
[11] Kamali, A. (2018): Investigating the Usability of UAV (Drone) Technology in the Logistics Industry in Bahrain. – Ciit International Journal 9: 12p.
[12] Mekdad, Y., Aris, A., Babun, L., El Fergougui, A., Conti, M., Lazzeretti, R., Uluagac, A.S. (2023): A survey on security and privacy issues of UAVs. – Computer Networks 224: 25p.
[13] Merkert, R., Bushell, J. (2020): Managing the drone revolution: A systematic literature review into the current use of airborne drones and future strategic directions for their effective control. – Journal of Air Transport Management 89: 11p.
[14] Mittendorf, C., Franzmann, D., Ostermann, U. (2017): Why would customers engage in drone deliveries? – Americas Conference on Information Systems 10p.
[15] Park, J., Kim, S., Suh, K. (2018): A comparative analysis of the environmental benefits of drone-based delivery services in urban and rural areas. – Sustainability 10(3): 15p.
[16] Prakash, S., Kumar, M., Jat, D., Jyoti, B., Subeesh, A., Agrawal, K., Tiwari, P., Mehta, C., Singh, P., Singh, K.K. (2022): Applications of drones in agriculture: Status and scope. – Indian Council of Agricultural Research 36p.
[17] Ramadan, Z.B., Farah, M.F., Mrad, M. (2017): An adapted TPB approach to consumers' acceptance of service-delivery drones. – Technology Analysis & Strategic Management 29(7): 817-828.
[18] Ravich, T.M. (2015): Courts in the drone age. – Northern Kentucky Law Review 42: 161-176.
[19] Sekaran, U., Bougie, R. (2016): Research methods for business: A skill building approach. – John Wiley & Sons 447p.
[20] Stolaroff, J.K. (2014): The need for a life cycle assessment of drone-based commercial package delivery (No. LLNL-TR-652316). – Lawrence Livermore National Laboratory (LLNL), Livermore, CA (United States) 4p.
[21] Stolaroff, J.K., Samaras, C., O'Neill, E.R., Lubers, A., Mitchell, A.S., Ceperley, D. (2018): Energy use and life cycle greenhouse gas emissions of drones for commercial package delivery. – Nature Communications 9(1): 13p.
[22] Usmanova, D. (2019): The drones are coming: Fostering acceptance within the implementation of unmanned aerial vehicle surveillance. – University of Twente 37p.

[23] Yoo, W., Yu, E., Jung, J. (2018): Drone delivery: Factors affecting the public's attitude and intention to adopt. – Telematics and Informatics 35(6): 1687-1700.