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# INTEGRATED EXPERT MODEL FOR RISK ASSESSMENT AND ENSURING THE SAFETY OF TOURIST TRIPS: ECONOMIC AND TECHNOLOGICAL ASPECTS

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**Abstract.** This study aims to develop an integrated expert model for assessing and ensuring the safety of tourist trips, with a particular emphasis on the economic and technological aspects. The model adopts a multi-level approach, spanning from individual perceptions of safety during travel to national assessments of regional tourism security. The economic factors, such as the financial implications of safety measures and their impact on regional tourism development, play a central role in this approach. The methodological foundation includes the theory of fuzzy sets and fuzzy logic, expert evaluations, and knowledge-based intelligent analysis. For the first time, we received: an information model for assessing the safety level of a tourist trip; a fuzzy method for determining the aggregated term risk assessment of one's safety of a tourist trip; an expert method of assessing the level of the sense of security of the region on the part of the participants of the tourist movement; a hybrid method of determining the degree of risk to the safety of a tourist trip. The model not only provides a quantitative assessment but also highlights the safety risks associated with tourist trips, thereby enabling regional analyses that support decision-making aimed at ensuring tourism safety through both economic and technological means solutions.

**Keywords:** integrated expert systems, economic aspect, economic impact, cost-effectiveness, intellectual analysis of knowledge, fuzzy modeling, economic risks, regional tourism.

**JEL Classification:** L20, L83, C02, C51, C55.

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## 1. Introduction

The issue of exploring the security risks and the risk factors in the tourism industry has become more and more current. Every travel process, tourist destination, and tourism activity involves a certain risk level. The tourism development is also accompanied by the emergence of new risk factors with the unpredictable impacts. In the recent period, the research trajectories have focused on the different risk dimensions, the assessments of risk perception, the behavioural risk aspects, and the risk influence on travelers' attitudes have been intensively investigated, but the investigation of impact frameworks is still missing (Lee et al., 2021; Williams & Baláž, 2013). It is clear from many studies that tourism risk perception is a multidimensional concept that consists of various travel and destination risk factors (Yang & Nair, 2014; Garg, 2015; Carballo et al., 2017). Risk perception by tourists is a subjective matter that results in the different evaluation results, even if the same objects are offered to all the tourists. For a long period, research of the relationships between the tourism risk dimensions and the concepts of behavioural science, which attitudes, behavioural intentions, and tourist satisfaction are throughout the period investigated in (Karl & Schmude, 2017; Caber et al., 2020).

Being in an unfamiliar environment, which is different from the place of permanent residence, the participants of the tourist movement are constantly under the influence of various risk factors. The tourist does not know the customs, language, traditions, and lifestyle perfectly, is not immune to the diseases common in the given area, or is not adapted to living and intense loads in the mountainous area, in the forest, or on the water. The safety of tourism is the basis of the formation of the strategic potential for the development of tourism in the region. The assessment of the level of tourism security should be related to the analysis of current risk-oriented factors affecting the security of the regional tourism system, as well as the identification of potential in the context of its further development. For example, the main factors of danger: are the trauma-danger, dangerous effect of the environment, including production sources – noise, vibration, fire hazard, chemical, radioactive, biological, psychophysical, natural, and personal safety in conditions of a criminogenic state, as well as specific risk factors, characteristic of special types of tourism. The best way to investigate the risk factors in one or another destination can only be done directly by the participants of the tourist movement. In addition, the region or the state as a whole should know the safety risks of tourists, and their proper management will lead to the development of regional tourism.

Our research is aimed at an integrated assessment of the degree of the security risk of a tourist trip, considering: the attitude of tourists to their own safety and harassment at the destination; the predicted level of repeated visits to the region by participants of the tourist movement; expert level security of regional tourism systems. The integrated model is based on the vertical from the personal individual sense of safety of the tourist trip up to the national level of safety of regional tourism. To formalize the integrated expert model, the mathematical apparatus of the theory of fuzzy sets and fuzzy logic, expert evaluation, and intellectual analysis of knowledge is used.

In this regard, the integrated model is divided into three stages:

- The first stage is the individual level of security of the tourist trip. In the first stage, based on the group's safety criteria and harassment at the destination, the resulting terms are determined based on the fuzzy rules of belonging.
- The second stage is the regional level of tourist trip security. At this stage, the data aggregation of the generalized value of the safety risk of the tourist trip and the predicted level regarding the repeated visit to the region, represents the level of the sense of safety of the region on the part of the participants of the tourist movement.
- The third stage is the national level of tourist safety. Here, a quantitative assessment and the degree of risk to the safety of a tourist trip are derived, taking into account the level of the sense of security of the region on the part of the participants of the tourist movement and the expert level of the regional tourism systems.

The essence of the model will be that, based on the attitude of the participants of the tourist movement regarding their safety and harassment at the destination, the predicted level of repeated visits to the region, and the expert level of safety of regional tourism systems, it derives a quantitative assessment and the degree of risk of the safety of the tourist trip. This will allow analyzing the region from the point of view of the safety of tourist trip, taking into account the safety of regional tourism systems, which contributes to the understanding of both the consumer behavior of the market and the general trends of the development of regional tourism.

In response to the above facts, it was decided to conduct an actual scientific study, the main purpose of which is to develop an integrated expert model for risk assessment and ensuring the safety of tourist trips, using the example of the countries of the Visegrad Group (Czech Republic, Hungary, Poland, Slovakia).

The study originality lies in the fact that the assessment model of the security risks of the tourist tours has not yet been created. It would consider the risks in an integrated framework by interconnecting the three levels – the individual, regional, and national levels. This also creates a wide scope for its use in practice, not only for the construction of the policies, regional development, competitiveness of the regions and the countries, but also for ensuring regional and national security.

Based on the above, the scientific hypothesis of the study can be formulated as follows. Suppose participants in the tourist movement in the selected region highly assess the safety of the destination. In that case, there is a high probability of repeat visits to the region by these participants. A high expert assessment of regional tourist systems is obtained, then this indicates a low level of tourist travel safety risk, determined based on the proposed model.

Despite the large number of studies on risks in tourism, there is no integrated model for assessing the safety levels of tourist trips that would take into account the subjective perception of tourists, regional expert assessment, and the national level of risks.

## 2. An overview of existing research

Natural disasters, environmental and health risks have arised deeper research of their effects on the decision-making processes of tourists and traveller's, as well as the impacts of risks on the demand for tourism services and the tourism industry. More and more factors affect the travel decisions with some factors also affecting tourism on a global scale (terrorist attacks, economic and pandemic crises) (Agarwal et al., 2021). The decision-making process of tourists has become more and more comprehensive. There may be differences in perception of the security risks and concerns about them among tourists from the different countries and continents, as well as the differences in the travel intentions. Some studies confirm the influence of the socio-demographic factors on the different perceptions of the travel risks and safety – for instance, age, education, status, religious affiliation (Reisinger & Mavondo, 2006; Simpson & Siguaw, 2008), and so on.

Despite these facts, little attention has been paid so far to the study of the differences in the sensitivity of risk perception among tourists, as well as to the study of an attractiveness level of the individual tourism segments in a relation to the external risks in international travel. Many research studies categorise risks in various ways with the division of risks into psychological and physical being the most widely applied. These can be influenced by the different factors and the individual events (Sohn et al., 2016; Aliperti & Cruz, 2019).

## 2.1. Tourists' perception of security risks in the context of economic and technological aspects of regional tourism safety

Although some tourists may perceive the risk environment as exciting, risk in tourism is seen mostly as a costly restrictive process that is unbalanced with the tourism benefits. Many research studies examine a wide spectrum of the security risks, but a majority of the studies examine the impacts of these risks on the tourism industry rather than their impact and prevention (Hajibaba et al., 2016; Balli et al., 2019). Also, there is little information about what can influence changes in tourists' risk perception and the impact of these changes on tourists' decision-making processes. There is a certain critical value for tourists' perception of travel risk with cognitive ability being an important factor affecting tourists' level of objective risk perception (Cui et al., 2016; Yang & Nair, 2014; Karl & Schmude, 2017).

The market segments with the different patterns of risk perception may also differ in the behavioural and personal characteristics, while the cultural factors (Seabra et al., 2013), high education level (Karl & Schmude, 2017; Ghosh & Batabyal, 2022; Šagovnović & Kovačić, 2021) and high frequency of travel (Karl, 2018) are also important. Fletcher and Morakabati (2008) also examined the differences of the external risks impact. They state that political events such as a coup d'état and the domestic political problems have more serious impacts on the tourism activity level than a single low-level to medium-level terrorist attack.

When exploring the risk perception factors, authors often distinguish between the objective and subjective factors of tourism risk perception. The authors examine the physical characteristics and the psychological processes within the subjective factors. The objective factors involve several dimensions: physical, economic, social, psychological, time dimensions of the loss opportunities.

Travel risk has always been perceived as a complex of the risks related to the observed destination and tourists. According to Reisinger and Mavondo (2005), travel risk perception was a function of a cultural orientation and the psychographic factors, while distress was a function of the perceived risk. The most significant predictors of travel distress were terrorism and sociocultural risk.

The food safety risks in the international destinations can also represent a special category of the tourist security risks as pointed out by Yeung and Yee (2013). The authors appeal for the construction of the tools for assessment of the social and economic impact on the risk perception by tourists in international tourism. The absence of these tools is also the reason, why the relationships between the tourists' risk perception and their satisfaction and loyalty have not been explored yet (Hasan et al., 2017).

Many authors mention that the COVID-19 pandemic has enabled a better understanding of the tourists' risk perception and to explore the determinants of the travelers' decision-making processes (Quan et al., 2022; Villacé-Molinero et al., 2021). An examination of the impact of the security measures on the restart of tourism has become a serious strategic issue in the tourism sector. Sharifpour et al. (2014) state in their study that it is necessary to investigate the impact of tourists' experience and knowledge as a multidimensional construct on their perceived risk. The various dimensions of the risk perception among tourists can also arise due to the application of the different information sources. Nagaj and Žuromskaitė (2020) perceive the security risks as a criterion for the competitiveness of accommodation facilities.

The competitiveness of these facilities also results from the security level and protection of the consumers of these services, while the quantity of these security measures is also important.

The importance of the health risks and their perception by travelers is documented in considerable detail, while the psychological sciences also tackle intensively with this area. Nevertheless, it is important to explore the deeper factors underlying the tourists' health risk perceptions and the risk-protective behaviour including in the context of sensation seeking (Chien et al., 2017). Wang and Karl (2021) develop a model based on the tourist-destination relationship and they propose an interdisciplinary plan to examine how tourists perceive security risks in the terms of health in the post-COVID-19 pandemic. Also Golets et al. (2023) point out that it is important to investigate the tourists behaviour and the factors influencing their travel plans after the COVID-19 pandemic, because the perception of the health risks and the impact of uncertainty on travel plans among tourists may have changed significantly in the post-pandemic period. Osland et al. (2017) claim that ecotourists with intense motivation for the selected destination are much more tolerant of the travel risks than tourists with social or occasional motivation.

A positive perception of hygiene and health in the particular destination can significantly influence tourists' satisfaction and loyalty (Tasci & Boylu, 2010). Zou and Yu (2022) consider destination safety, safety climate and the safety role as an important subdimension of the destination image. Recently, there have also appeared the studies focused on the ecological safety that has an impact on several dimensions. Ying et al. (2022) investigate the areas of the tourism ecological safety, ecological risk, and ecological health. They appeal to the need to strengthen research on the threshold values, early warning systems and regulations, and big data application, to build the mechanisms of the synergic effects between ecology and tourism development, and to carry out the longitudinal studies.

## 2.2. Fuzzy approaches for assessing security risks in tourist travel: economic and technological perspectives

The issue of investigating the security risks associated with tourism is still insufficiently conceptualised, there is a missing suitable integrated framework for the risk perception in tourism, as the available research studies tend to be empirically distorted. This causes the theoretical frameworks to be underutilised or only partially applied (Hsu & Lin, 2006).

The fuzzy approaches have become increasingly applied in solving the individual as well as complex problems in the tourism industry and thus, they are not the only complementary methods but also substitutes. Their preferences are justified by the strong potential for solving the integrated tasks in the conditions of risk and uncertainty. Some studies explicitly pay an attention to the fact that traditional security risk assessment schemes in the tourism industry cause the large errors in evaluation that have encouraged the reevaluation of these methods. Guo (2021) proposed a security risk assessment scheme for the tourism management systems based on the PSO-BP neural networks that can effectively assess the security risks of the tourism management systems. Fu and Tzeng (2016) propose a new procedure based on the fuzzy approaches with the multiple criteria (MCDM) in the investigation of the security risks. They integrate Fuzzy MCDM with a language scale that transforms the subjective knowledge of the expert groups into a set of the objective safety management indicators for the hot spring hotels.

Faraji Sabokbar et al. (2016) investigated the travel risk factors within the dimensions of the internal risks and external risks and the seven criteria: political, economic, cultural-social, technological, environmental-health, functional, and safety criteria. They proposed a fuzzy expert system through a knowledge base that can be a suitable tool for forecasting risks, fluctuations and negative impacts on the development of destinations. For the future development of destinations, the study of the risk effects and their interaction is considerably important.

The security risks can also be perceived through the climatological parameters that is also declared by the study of Dávila-Lamas et al. (2022). The authors proposed a fuzzy analytical hierarchy process (FAHP), to evaluate the coastal and climatological parameters that represent a part of the monitorable security risks of tourists. This model can help to prevent the accidents and the dangerous situations.

The tourist destinations should have prepared the risk management processes not only for the most likely risks, but also for the worst case scenarios. Fuzzy logic in a combination with the other techniques have been increasingly applied in prioritising the risk factors and investigating the differences in the risk perception at the different levels and in the various population and socio-demographic groups of visitors. Zhu et al. (2021) recommends to employ the fuzzy approaches for prioritisation of the risk factors. In their study, they applied the Fuzzy AHP_PROMETHEE approach that helps to evaluate the market risks of new cruise ships. These tools will support the sustainable development of river navigation. Lin and Hsu (2013) recommend to apply the approaches based on fuzzy logic when investigating the tourists' risk perception. They recommend to employ a hierarchy value map that fuses the attribute–consequence–value and fuzzy linguistics in order to enable a better understanding of the tourism risks and the risk factors. Weifeng (2005) creates a list of the safety components in order to quantify the risks perceived by tourists considering different uncertainty levels. As a suitable complementary tool in these processes, it engages the analytical hierarchical process method to determine the weights of the various criteria of the evaluated risks and the subjective attitudes of the evaluators.

Some authors perceive the importance of the research of the risk tourism factors in the particular destination to ensure its further development. Also in these studies, the authors apply Fuzzy models aimed at assessing the security risks in the regions. For instance, Hosseini et al. (2021) examined the risk assessment criteria from the fields of social culture, environment, finance, protection, and security. They employed the fuzzy decision-making trial and evaluation laboratory (FDEMATEL) method to create a fuzzy influential network relation map and thus, to find the fuzzy influential weights. The safety and security risks had the most significant impact, while the socio-cultural, financial, and environmental risks had a lower impact. Wu et al. (2019) applied a fuzzy approach for risk assessment of the rural tourism projects. The authors extend the VIKOR method to the multiple attribute decision-making with the interval-valued intuitionistic fuzzy numbers (IVIFNs). The advantage of IVIFNs is that it can fully take into consideration the bounded rationality of the decision makers. The other studies also examine the security risks as a part of the regional development processes employing the fuzzy approaches that confirm their importance for the regional development policymakers.

Ranjan Debata et al. (2013) employed a fuzzy approach in order to create a integrated framework for identifying and classifying the key factors enabling the development of medical tourism. They developed an integrated approach employing the interpretive structural modelling and Fuzzy Matrice d'Impacts Croisés Multiplication Appliquée á un Classement (FMICMAC) to classify the key activators of medical tourism. The FMICMAC analysis enables the investigation of the relationships between the different factors and thus, to identify the hidden factors that may later have a significant impact and have become the significant medical tourism risks. Vena-Oya et al. (2022) consider the fuzzy approaches to be more effective for the development of the methods that allow the provision of the consistent and reliable scenarios for the impact elimination of the health risks as the case with the consequences of COVID-19 was. The fuzzy cognitive maps will support the construction of the flexible and adaptable scenarios that are more effective than the current econometric models.

The environmental risks are examined in a relation to the geographical aspects of economic development and tourism. The fuzzy approaches are applied as an effective tool for an elimination of these risks. Kanga et al. (2013) developed a fire hazard minimisation model employing Multi-Criteria Decision Analysis (MCDA), Analytic Hierarchy Process & Fuzzy techniques and tourism model. The fuzzy approaches have also proven to be efficient for e-tourism investment risk analysis. This is also proven by the outcomes of the Paudel and Hossain (2006) study, which the fuzzy rule-base has been developed to calculate the risk factors for the e-tourism investment in.

Fuzzy approaches are important for assessing security risks in tourism, especially in the context of geopolitical risks and pandemics, as they allow considering uncertainty and subjective factors that cannot be accurately measured by traditional methods. Combined with AI tools that can process large amounts of data and detect patterns, fuzzy models provide greater flexibility in decision-making, allowing security strategies to be adapted to changing conditions. This combination of approaches can be applied at different levels – individual, regional, and national – to assess risks and develop effective risk management measures in tourism.

The results of the available research studies clearly declare the missing security risk investigation and the evaluation processes linking risks at the different levels from individual through regional to national. This association of the levels of the investigated risks would enable to take into consideration several kinds of the risks and their determinants in a complementary way in a single area and a time period. Such a systemic approach would allow the construction of the conceptual models covering a wide range of the risks and thus drawing an attention to the activators of their occurrence and the possibilities of their elimination. At the same time, it would make it possible to reveal the other determinants of the risk emergence that would not be possible to reveal during a single-level evaluation of the security risks. This would help to create the synergistic mechanisms and new analytical and evaluation platforms with an association to the satisfaction and loyalty of tourists and the competitiveness of the destinations. These facts were the motivation to carry out our research and to create an expert model of the security risk evaluation in the tourism industry.

Despite the rich array of studies related to the perception of tourist risks, the impact of risks on tourist behavior, and the impact of external factors on tourism safety, a single integrated model has not yet been created that would consider subjective and objective levels of safety assessment. The issue of harmonizing different levels of risk assessment – individual, regional, and national – also remains insufficiently studied.

The conducted research has the following structure. Section 3 describes the formal formulation of the problem and the integrated expert model for risk assessment and ensuring the safety of tourist trips, which consists of three stages: individual, regional and national levels of tourist safety. In Section 4, the verification and testing of the integrated expert model is carried out and an example of evaluation on real data is given. Section 5 discusses the results of the research. Section 6 presents the main results obtained for the first time. Ideas for the future development of regional tourism are defined here, namely the development of integrated information technology and software to support decision-making in the tourism business, market, and economic research.

## 3. Materials and methods

### 3.1. Formal formulation of the evaluation problem

To assess the degree of risk of the safety of a tourist trip, a certain region is considered $R$. The number of participants in the tourist movement is indicated $E = \{e_1; e_2; \ldots; e_n\}$. They have visited the destination and express their attitude regarding the impression, anxiety and concern regarding aspects of their own safety and harassment according to the risk groups of the evaluation criteria $G_1; G_2; ...; G_l$.

Then, the integrated expert model of evaluation and derivation of the quantitative assessment and the degree of risk of tourist safety is illustrated in the form of the following operator:

$$\Xi(R, E, m_{RV}, \Delta_{ST}, K_{RS}, M_{RT}, M_{ES}, M_{HR}) \rightarrow f(\mu_{SR}, T_{SR}). \tag{1}$$

Where $\Xi$ – the operator that is based on the input variables $R, E, m_{RV}, \Delta_{ST}, K_{RS}, M_{RT}, M_{ES}, M_{HR}$ outputs the output values *f*: quantitative assessment $(\mu_{SR})$ and the degree of the security risk of the tourist trip $(T_{SR})$, which takes into account the level of the sense of security of the region on the part of the participants of the tourist movement and the expert level of security of regional tourism systems. The input values are as follows: $m_{RV}$ – the predicted level of repeated visits to the region by participants of the tourist movement; $\Delta_{ST}$ – expert level of security of regional tourism systems; $K_{RS}$ – information model for assessing the safety level of tourist trip; $M_{RT}$ – a fuzzy method for determining the aggregated term risk assessment of one's safety of a tourist trip; $M_{ES}$ – an expert method of assessing the level of the sense of security of the region on the part of the participants of the tourist movement; $M_{HR}$ – a hybrid method of assessing the degree of risk to the safety of a tourist trip.

The integrated expert assessment model serves as an expert system. It presents the knowledge of participants in the tourist movement and tourism experts. This model includes the following management subjects: participants in the tourist movement – experts (respondents of the research questionnaire) who expressed their opinions regarding their own safety and harassment at the destination; a system analyst is a person who configures all processes of evaluating a integrated expert model; a decision maker (DM) is a person who makes further decisions based on the derived degree of safety risk of a tourist trip, for example for the purpose of adopting regional tourism policies or market research.

According to the purpose of the study, the decision-maker can be:

- Representatives of local authorities – in particular, tourism departments, who are responsible for developing tourism development strategies and ensuring the safety of tourist destinations.
- Heads of travel agencies – who are interested in analyzing risks to form safe routes and increase the attractiveness of their offers.
- Experts in the field of safety and tourism – who can use the model to independently assess risks and provide recommendations.

For a better understanding, the integrated expert model for risk assessment and ensuring the safety of tourist trips: economic and technological aspects, is presented in the form of a structural diagram, Figure 1.

Figure 1 reflects the structural diagram of the integrated expert model for risk assessment and ensuring the safety of tourist trips: economic and technological aspects. Here we have: $tr^*(e)$ – aggregated term risk assessment of one's safety of a tourist trip; $\mu_{ES}(R)$ – the level of feeling of security in the region on the part of the participants of the tourist movement; $\mu_{SR}(R)$ – normalized assessment of the safety risk of a tourist trip; $T_{SR}$ – linguistic interpretation of the degree of safety risk of a tourist trip. After the evaluation, the following is built: an aggregated term estimate of the risk to one's safety of the tourist trip for some experts in the visited region; the generalized significance of the safety risk of tourist trip for the region; the level of feeling of safety of the region on the part of the participants of the tourist movement;

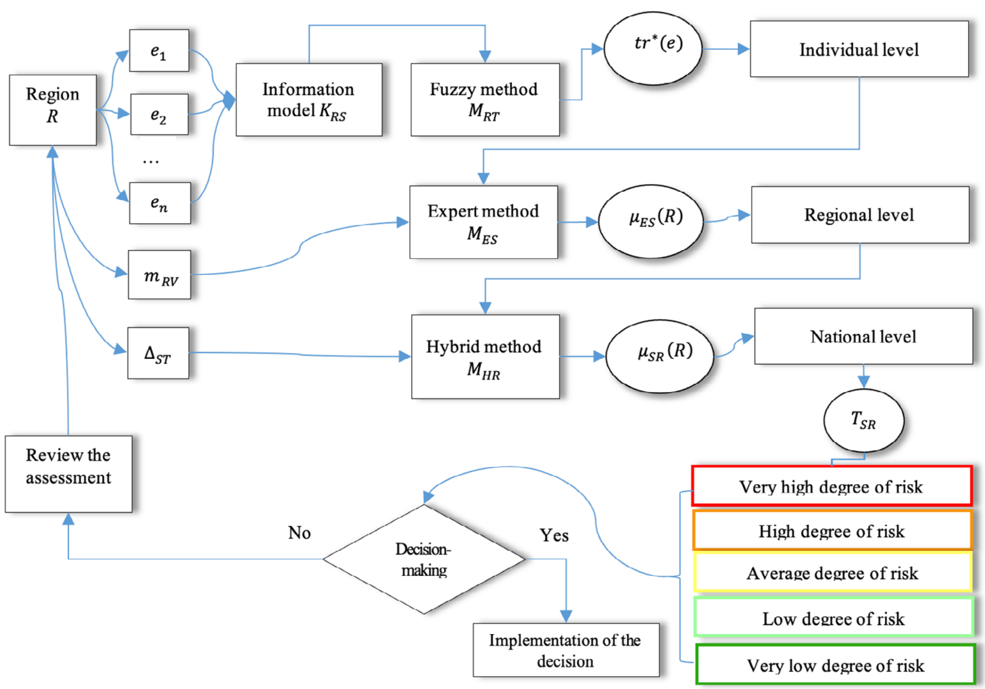


**Figure 1.** Structural diagram of the integrated expert model for risk assessment and ensuring the safety of tourist trips: economic and technological aspects

quantification and degree of risk of tourist trip security. Based on the initial data, the DM decision is made regarding future scenarios to support decision-making from the point of view of the safety of tourist trip, for all interested parties, such as tourists, businesses, and public authorities, which in the integrated contributes to the development of regional tourism. If the degree of risk of tourist trip security across regions does not satisfy the DM, then there is an opportunity to revise the assessment by adjusting the parameters of the expert model.

A three-stage integrated expert model is presented.

*The first stage of the integrated model is the individual level of security of the tourist trip*. At this stage, calculations are made separately for tourists. For this, the $K_{RS}$ information model is presented, which is based on the evaluation of the safety level of the tourist trip and the fuzzy $M_{RT}$ method of determining the resulting terms based on the rules of belonging.

$K_{RS}$ – *information model for assessing the safety level of tourist trip*

Let a set of evaluation criteria be proposed $K=\left\{K_i; i=\overline{1,m}\right\}$ own safety and harassment at the destination, which is divided into $l$ groups $G_1; G_2; ...; G_l$. Participants of the tourist movement according to each evaluation criterion, using linguistic variables $T=\left\{t_1;\ t_2;\ t_3;\ t_4;\ t_5\right\}$, express their attitude regarding their safety and harassment at the destination. Linguistic variables are proposed to express the following meaning: $t_1$ – "Strongly disagree"; $t_2$ – "Disagree"; $t_3$ – "Neither agree nor disagree"; $t_4$ – "Agree"; $t_5$ – "Strongly agree".

The set of criteria includes the impressions, worries and concerns of the participants of the tourist movement regarding their own safety and harassment at the destination. The following groups and their evaluation criteria are proposed for the interpretation of the information model.

$G_1$ – Security risks related to the infrastructure of the destination.

$K_{11}$ – The warning information on public information boards is not clear enough for me, reducing my confidence in safety management and discouraging me from spending on local guided tours or activities.

$K_{12}$ – In my opinion, there is an insufficient number of objects that control the safety of tourists, which affects my trust in the destination's investment in safety infrastructure, ultimately influencing my spending decisions.

$K_{13}$ – I was concerned about the chaos and traffic safety, making me avoid using local transportation services, which impacts the revenue of these services.

$K_{14}$ – I was concerned about the security of the residence, which led me to prioritize higher-cost accommodations with better safety guarantees, affecting my overall travel budget.

$K_{15}$ – While traveling by car, I was afraid of a traffic accident, which discouraged me from renting vehicles locally or exploring less-developed areas, reducing potential economic contributions.

$G_2$ – Social and environmental safety risks in tourism.

$K_{21}$ – I was concerned about serious environmental pollution at the tourist destination, which diminished my willingness to stay longer or spend more on local eco-tourism experiences.

$K_{22}$ – I was afraid of crowds in tourist places, which made me avoid popular attractions and events, affecting their ticket sales and revenue.

$K_{23}$ – I preferred supermarkets and specialty shops because I feared the local merchants would rob me, limiting my engagement with and spending in local markets.

$K_{24}$ – I was worried about the bad attitude of local workers towards tourists, which made me less likely to use local services or recommend the destination to others, indirectly affecting future economic benefits.

$K_{25}$ – I was worried about the hostile attitude of residents towards tourists, which influenced my decision to avoid smaller local communities, reducing economic benefits for these areas.

$K_{26}$ – I was concerned that residents were not allowing tourists into local communities, restricting my willingness to explore and engage in cultural exchange, which often involves spending on local goods and services.

$K_{27}$ – I was concerned about violating hidden local or cultural customs and rules, making me hesitant to participate in local traditions or spend on unique cultural experiences.

$G_3$ – Health safety risks in tourism.

$K_{31}$ – The quality and safety of local produce and food were a concern for me, which made me avoid spending on local culinary experiences and opt for international or packaged options instead.

$K_{32}$ – I was concerned about safety due to a possible threat to my overall health, which made me reconsider visiting certain areas, reducing economic contributions to local businesses in those locations.

$K_{33}$ – I was worried about my health due to the assumption about the possible occurrence of certain viral diseases at the destination, leading me to allocate more resources to healthcare precautions, diverting funds from other local expenditures.

$K_{34}$ – I was worried about safety because of the possible threat to my health caused by the environment itself, discouraging me from spending on outdoor recreational activities.

$K_{35}$ – I was concerned about safety because of the possible threat to my health caused by the infrastructure, which affected my trust in local healthcare services and made me prioritize spending on safer, higher-cost alternatives.

$G_4$ – Harassment risks at the destination.

$K_{41}$ – I was not satisfied with the initiatives to sell the product, which made me reluctant to shop locally, reducing the revenue of small businesses.

$K_{42}$ – I met people who asked me for money, which made me feel uncomfortable in public places, discouraging me from spending time and money in crowded areas.

$K_{43}$ – I felt oppression from sellers, which discouraged me from engaging with local markets, impacting their overall income.

$K_{44}$ – I was offered drugs, and the dealer was pushy or obnoxious, which made me avoid nightlife or certain areas, reducing potential economic activity.

$K_{45}$ – I was often offered and forced to engage in activities that were not interesting to me, which made me avoid local entertainment or recreational services, reducing my economic contributions.

Of course, the group of criteria is open, and the model does not depend on the number of groups or criteria.

*$M_{RT}$ – a fuzzy method for determining the aggregated term risk assessment of one's safety of a tourist trip*

A set of input linguistic variables is obtained based on the impression of the participants of the tourist movement regarding visiting the region, concern for their own safety and harassment at the destination. In the first step, the membership rules and the knowledge base are presented to obtain one resulting term estimate $T_g$ for each group of risk assessment criteria. In the second step, based on the obtained grades $T_g$ about a certain participant in the tourist movement *e*, an aggregate risk assessment of one's own safety of a tourist trip is determined as one of the indicators of an integrated expert model for deriving the degree of risk of safety of a tourist trip in the region *R*.

First, a transition is made from the linguistic reasoning of experts for each criterion to one resulting term assessment for groups of risk criteria. For this purpose, each linguistic variable is assigned some quantitative assessment τ, which has the following logic. The less anxiety and concern of the participants of the tourist movement regarding their safety and harassment at the destination, the greater the value of the quantitative assessment τ. Then, without reducing the generality, the quantification is proposed to be expressed using the following characteristic function:

$$\tau = \begin{cases} \tau_1 = 1 & \text{if } t_1 - \text{"Strongly disagree"}, \\ \tau_2 = 2 & \text{if } t_2 - \text{"Disagree"}, \\ \tau_3 = 3 & \text{if } t_3 - \text{"Neither agree nor disagree"}. \\ \tau_4 = 4 & \text{if } t_4 - \text{"Agree"}, \\ \tau_5 = 5 & \text{if } t_5 - \text{"Strongly agree"}. \end{cases} \tag{2}$$

Further, within the limits of the group of risk criteria is the sum of the values of quantitative assessments by some expert *e*:

$$\theta_g = \sum_{i=1}^{m_g} \tau_{gi}, \ g = \overline{1,l}, \tag{3}$$

where $m_g$ – the number of criteria in the group *g*.

The following characteristic function is used to derive the resulting term estimate by groups of risk criteria:

$$T_g = \begin{cases} t_1 & \text{if } \theta_g < m_g, \\ t_2 & \text{if } m_g \le \theta_g < 2m_g, \\ t_3 & \text{if } 2m_g \le \theta_g < 3m_g, \quad g = \overline{1,l}. \\ t_4 & \text{if } 3m_g \le \theta_g < 4m_g, \\ t_5 & \text{if } \theta_g \ge 4m_g. \end{cases} \tag{4}$$

Thus, for each group of risk criteria g, one resulting term estimate is derived from a set of linguistic variables *T*. At this stage, we have the following data, Table 1.

Next, the aggregate risk assessment of one's safety on the tourist trip is determined. For this, let the object with *g* inputs and one output be analyzed:

$$tr^*(e) = L(T_1, T_2, \dots, T_l), \tag{5}$$

where: $tr^*$ – initial resulting linguistic assessment for the group of risk criteria *g*; $T_1, T_2, \dots, T_l$ – input linguistic evaluations, respectively, by some expert *e*. *L* – the operator matching the initial resulting term estimate $tr^*$, with the input variables $T_1, T_2, \dots, T_l$ (the rule of logical inference). Let the following term-set of linguistic variables of the risk of one's safety of a tourist trip be offered: $TR = \{L;\ BA;\ A;\ AA;\ H\}$, $tr^* \in TR$, *L* – "low risk"; *BA* – "risk below average"; *A* – "average risk"; *AA* – "above average risk"; *H* – "high risk".

**Table 1.** Input data for visiting a region $R$ an expert $e$

| Criterion group | Criterion | Linguistic assessment | Quantitative assessments | Sum | The resulting term evaluation |
|---|---|---|---|---|---|
| $G_1$ | $K_{11}$ | $T_{11}$ | $\tau_{11}$ | $\theta_1$ | $T_1$ |
| | $K_{12}$ | $T_{12}$ | $\tau_{12}$ | | |
| | … | … | … | | |
| | $K_{1m_1}$ | $T_{1m_1}$ | $\tau_{1m_1}$ | | |
| $G_2$ | $K_{21}$ | $T_{21}$ | $\tau_{21}$ | $\theta_2$ | $T_2$ |
| | $K_{22}$ | $T_{22}$ | $\tau_{22}$ | | |
| | … | … | … | | |
| | $K_{2m_2}$ | $T_{2m_2}$ | $\tau_{2m_2}$ | | |
| … | … | … | … | … | … |
| $G_l$ | $K_{l1}$ | $T_{l1}$ | $\tau_{l1}$ | $\theta_l$ | $T_l$ |
| | $K_{l2}$ | $T_{l2}$ | $\tau_{l2}$ | | |
| | … | … | … | | |
| | $K_{lm_l}$ | $T_{lm_l}$ | $\tau_{lm_l}$ | | |

where $T_{gm_g}$ – linguistic evaluations of the g-*th* group of criteria, $\tau_{gm_g}$ – a quantification obtained using a characteristic function (2), $\theta_g$ – the sum of the values of the quantitative estimates obtained by the formula (3), $T_g$ – the resulting linguistic score obtained by the formula (4), $g = \overline{1,l}$.

Next, it is necessary to construct the rules of belonging to the resulting terms. Such rules are proposed to be built in percentage terms of the ownership of certain terms of the input variable. Formally, the membership rules represent a system of logical statements – "*If*, *Then*, *Else*", which connect the values of the input variables $T_1, T_2, ..., T_l$ with one of the possible values of the output variable $TR$, for example:

**If** ($G_1$ = $t_5$ and $G_2$ = $t_5$ and … and $G_l$ = $t_5$) or ($G_1$ = $t_5$ and $G_2$ = $t_5$ and … and $G_l$ = $t_4$) or … or ($G_1$ = $t_5$ and $G_2$ = $t_4$ and … and $G_l$ = $t_5$) **Then** $tr^* = L$, **Else** ……………………………………………………………………………………………………………………………… **If** ($G_1$ = $t_3$ and $G_2$ = $t_3$ and … and $G_l$ = $t_3$) or ($G_1$ = $t_3$ and $G_2$ = $t_3$ and … and $G_l$ = $t_2$) or … or ($G_1$ = $t_2$ and $G_2$ = $t_1$ and … and $G_l$ = $t_1$) **Then** $tr^* = H$.

Similarly, all functional dependencies are formed, which embody the decision-making rules in mathematical form, which collectively form the knowledge base. For example, the eligibility rules for deriving an aggregate risk assessment of one's security of a tourist trip, for the proposed information model, are proposed to be formulated as follows, the Table 2.

As can be seen, based on the constructed rules of relevance for deriving the risk to one's safety during a tourist trip according to groups of risk criteria, the following fragment of the knowledge base is presented, in Table 3.

Thus, at the output of the fuzzy method – $M_{RT}$ an aggregated linguistic assessment $tr^*(e)$ of the risk of one's safety of the tourist trip for the expert $e$ in the visited region $R$ is derived.

*The second stage of the integrated model is the regional level of tourist trip security*. At this stage, the calculation takes place within the region, for this purpose the data aggregation of the generalized value of the safety risk of the tourist trip and the predicted level of re-visiting the region is carried out using an expert method $M_{ES}$.

**Table 2.** Appropriateness rules for deriving an aggregated risk assessment of one's security

| Rule number | The rule of belonging | Aggregate risk assessment of one's security of a tourist trip |
|---|---|---|
| 1 | If the number of the resulting term evaluation by groups of criteria is not lower:<br>1 with the term $t_5$ – "Strongly agree",<br>3 with the term $t_4$ – "Agree". | L – "low risk" |
| 2 | If the number of the resulting term evaluation by groups of criteria is not lower:<br>1 with the term $t_5$ – "Strongly agree",<br>1 with the term $t_4$ – "Agree",<br>2 with the term $t_3$ – "Neither agree nor disagree". | BA – "risk is below average" |
| 3 | If the number of the resulting term evaluation by groups of criteria is not lower:<br>1 with the term $t_4$ – "Agree",<br>2 with the term $t_3$ – "Neither agree nor disagree",<br>1 with the term $t_2$ – "Disagree". | A – "average risk" |
| 4 | If the number of the resulting term evaluation by groups of criteria is not lower:<br>2 with the term $t_3$ – "Neither agree nor disagree",<br>2 with the term $t_2$ – "Disagree". | AA – "above average risk" |
| 5 | For all others below cases. | H – "high risk" |

**Table 3.** Knowledge base fragment

| Rule number | $G_1$ | $G_2$ | $G_3$ | $G_4$ | Term assessment of the risk of one's own safety of a tourist trip |
|---|---|---|---|---|---|
| 1 | $t_5$ | $t_5$ | $t_5$ | $t_5$ | L – "low risk" |
| 2 | $t_5$ | $t_5$ | $t_5$ | $t_4$ | |
| 3 | $t_5$ | $t_5$ | $t_4$ | $t_4$ | |
| 4 | $t_5$ | $t_4$ | $t_3$ | $t_4$ | BA – "risk is below average" |
| 5 | $t_5$ | $t_4$ | $t_3$ | $t_3$ | |
| 6 | $t_5$ | $t_5$ | $t_5$ | $t_3$ | |
| … | … | … | … | … | … |

*$M_{ES}$ – an expert method of assessing the level of the sense of security of the region on the part of the participants of the tourist movement*

Thus, based on a fuzzy model for determining the aggregated term risk assessment of one's safety of a tourist trip in the visited region *R*, an aggregated linguistic risk assessment of one's safety of a tourist trip is obtained for each expert: $tr^*\left(e_1\right), tr^*\left(e_2\right), \ldots, tr^*\left(e_n\right)$.

First of all, one generalized value of the safety risk of tourist trip in the studied region *R* is calculated. All participants of the tourist movement, as respondents of the research questionnaire, are considered equally important. Otherwise, the DM may delimit their competencies by introducing weighting factors. The aggregate term risk assessment is naturally determined on a percentage scale (0–100%), each of which is assigned a value from some interval [*a*; *b*], for example: $L$ – [0; 15], $BA$ – [15; 30], $A$ – [30; 50], $AA$ – [50; 80], $H$ – [80; 100]. Next, the following value is taken into consideration:

$$\delta\left(e_j\right)=\begin{cases}15 & \text{if} \quad tr^*\left(e\right)=\mathrm{L}, \\ 30 & \text{if} \quad tr^*\left(e\right)=BA, \\ 50 & \text{if} \quad tr^*\left(e\right)=\mathrm{A}, \quad j=\overline{1,n}. \\ 80 & \text{if} \quad tr^*\left(e\right)=\mathrm{AA}, \\ 100 & \text{if} \quad tr^*\left(e\right)=H.\end{cases} \tag{6}$$

The characteristic function given above allows you to translate linguistic terms into a quantitative assessment, which enables further calculation and comparison. A weighted sum is used to derive one generalized value of safety risk of tourist trip:

$$\psi\left(R\right)=\frac{1}{n}\sum_{j=1}^{n}\delta\left(e_j\right), j=\overline{1,n}, \tag{7}$$

where $n$ – is the number of participants in the tourist movement in the region $R$. The generalized value of $\psi\left(R\right)\in\left[15;100\right]$ of the safety risk of the tourist trip obtained within the region characterizes the assessment of the sense of security of the region by the participants of the tourist movement in the region. The higher the value, the higher the security risk of the tourist trip and the sense of security in the region decreases. We can consider this dependence in the form of uncertainties of the "small amount" type, expressed by Z-like membership functions. For example, the quadratic Z-spline for this problem would look like:

$$m_{ES}\left(R\right)=\begin{cases}1, & \psi\left(R\right)\le 60; \\ 1-\dfrac{\left(\psi\left(R\right)-60\right)^2}{800}, & 60<\psi\left(R\right)\le 80; \\ \dfrac{\left(100-\psi\left(R\right)\right)^2}{800}, & 80<\psi\left(R\right)<100, \\ 0, & \psi\left(R\right)\ge 100.\end{cases} \tag{8}$$

The membership function setting parameters depend on the real data of the applied problem, which determines the limitations of the study.

The obtained value $m_{ES}\left(R\right)\in$ [0; 1], is a normalized generalized value of the safety risk of a tourist trip. When the value of $m_{ES}\left(R\right)$ approaches 1, then the risk of tourist trip in the study region is minimal.

Let the researched region $R$ have a predicted level of repeated visits to the region by participants of the tourist movement – $m_{RV}$. The value of this level is denoted by $m_{RV}\left(R\right)\in$ [0; 1], which conditions the potential possibility of repeated visits to the region and/or the attraction of new consumers of tourist services. The authors have already obtained this level in a previous study, and its values for V4 countries are given in (Data, 2023a). The higher the value of $m_{RV}\left(R\right)$, the greater the desire of tourists to visit the region again. In our study, it is assumed that when the participants of the tourist movement have the desire to visit the region again, then they were satisfied with the previous trip and felt safe in the region.

Thus, on the one hand, the generalized value of the safety risk of the tourist trip $m_{ES}(R)$, is obtained, and on the other hand, the predicted level of $m_{RV}(R)$ regarding repeated visits to the region by the participants of the tourist movement. It is proposed to use intellectual analysis of knowledge based on multidimensional functions of belonging to obtain the level of a sense of security of the region on the part of the participants of the tourist movement. So, as the values of $m_{ES}(R); m_{RV}(R)$ in the space of estimates [0; 1] are characterized by the uncertainty of the "average value" type, then you can use a cone-shaped or pyramidal membership function. For example, a cone-shaped membership function, with the center of the base of the cone at – $(1;1)$ and scaled by coordinates $(2;2)$, would look like:

$$\mu_{ES}^{1}(R) = 1 - \frac{1}{2} \cdot \sqrt{\left(m_{ES}(R) - 1\right)^2 + \left(m_{RV}(R) - 1\right)^2} \, . \tag{9}$$

The Equation for the pyramidal membership function in two-dimensional space will have the following form:

$$\mu_{ES}^{2}(R) = \max\left\{\left(1 - \frac{1}{2}\left(\left|m_{ES}(R) - 1\right| + \left|m_{RV}(R) - 1\right|\right)\right); 0\right\}. \tag{10}$$

The obtained values are normalized and characterize the level of feeling of security in the region on the part of the participants of the tourist movement. As you can see, from a mathematical point of view we have that $\mu_{ES}(R) \in$ [0.29; 1].

*The third stage of the integrated model is the national level of tourist trip security*.

At this stage, a quantitative assessment and the degree of risk of the safety of the tourist trip are derived using the proposed expert hybrid method $M_{HR}$, taking into account the level of the sense of security of the region on the part of the participants of the tourist movement $\mu_{ES}(R)$ and the expert level of security of the regional tourism systems $\Delta_{ST}$.

*$M_{HR}$ – a hybrid method of assessing the degree of risk to the safety of a tourist trip*

Let the regional tourist system, for this study, be the content of a integrated tourist system that is formed at the regional level under the influence of tourist flows, the main goal of which is the innovative and sustainable development of the tourism sphere of the region. At the current stage, the key direction of the development of the tourism sector is the guarantee of tourism safety. Then some $\Delta_{ST}$ – expert level of security of regional tourist systems is introduced, which represents some national comparative assessment in the region. To introduce such a level, the DM analyzes the region in terms of innovative and sustainable development of the region under the influence of tourist flows, after that it expresses its reasoning in the form of linguistic variables from the following term-set $\Delta_{ST} = \{\Delta_1; \Delta_2; \Delta_3; \Delta_4; \Delta_5\}$, where: $\Delta_1$ = {Low level of security of regional tourism systems}; $\Delta_2$ = {The security level of regional tourism systems is below average}; $\Delta_3$ = {Average level of security of regional tourism systems}; $\Delta_4$ = {The security level of regional tourism systems is above average}; $\Delta_5$ = {High level of security of regional tourism systems}.

In the form of an operator, a hybrid method of assessing the degree of safety risk of a tourist trip is formally presented:

$$A\left(\mu_{ES}(R);\ \Delta_{ST}(R)\right) \rightarrow f\left(\mu_{SR}, T_{SR}\right), \tag{11}$$

where $A$ – is an operator matching a set of initial values of $f$, given the input variables $\mu_{ES}(R);\Delta_{ST}(R)$ for some region. The input data of the method are the value of the regional level $\mu_{ES}(R)$, which is obtained from the feelings of security of the region on the part of the participants of the tourist movement; the value of the national level $\Delta_{ST}(R)$ of the safety of regional tourism systems. At the output of the evaluation model, we have: a quantitative estimate of $\mu_{SR}$ and the degree of risk to the safety of the tourist trip $T_{SR}$.

In the first step, the operation of fuzzification of the input hybrid data is performed. For this, each input value $(\mu_{ES}(R);\Delta_{ST}(R))$ is matched with the value of the membership function $\mu_{SR}(R)$. For this, it is necessary to build membership rules to obtain a normalized assessment of the input data.

Let the term-set of linguistic variables $\Delta_{ST}=\{\Delta_1;\Delta_2;\Delta_3;\Delta_4;\Delta_5\}$ be represented on some numerical interval to delimit the terms $[a_1; a_6]$, where $\Delta_1 \in [a_1; a_2]$, $\Delta_2 \in [a_2; a_3]$, $\Delta_3 \in [a_3; a_4]$, $\Delta_4 \in [a_4; a_5]$, $\Delta_4 \in [a_5; a_6]$. The values of the division of intervals can be adjusted and changed, based on the real data on the functioning of regional tourism.

To do this, the values of ξ, are calculated using the characteristic function, using the linguistic variables $\Delta_{ST}$, the quantitative estimates $\mu_{ES}$ and the values of the interval partitioning $[a_1; a_6]$:

$$\xi(R)=\begin{cases} a_2\cdot\mu_{ES}(R), & \text{if} \quad \Delta_{ST}(R)\in\Delta_1; \\ a_3\cdot\mu_{ES}(R), & \text{if} \quad \Delta_{ST}(R)\in\Delta_2; \\ a_4\cdot\mu_{ES}(R), & \text{if} \quad \Delta_{ST}(R)\in\Delta_3; \\ a_5\cdot\mu_{ES}(R), & \text{if} \quad \Delta_{ST}(R)\in\Delta_4; \\ a_6\cdot\mu_{ES}(R), & \text{if} \quad \Delta_{ST}(R)\in\Delta_5. \end{cases} \tag{12}$$

This will provide an opportunity to combine the quantitative assessments and opinions of the DM. As a result, an objective assessment of ξ($R$) is obtained regarding the safety of tourist trip in the region, which will lead to the validity of decision-making.

For an adequate interpretation of the dependence of the level of the region's sense of security on the part of the participants of the tourist movement and considering the considerations of the DM regarding the level of security of regional tourism systems, it is necessary to normalize the obtained estimates. Therefore, it is suggested to use an S-shaped membership function to compare the data using the representation of the membership rule:

$$\mu_{SR}(R)=\begin{cases} 0, & \xi(R)\le a_1 \\ 2\left(\dfrac{\xi(R)-a_1}{a_6-a_1}\right)^2, & a_1<\xi(R)\le\dfrac{a_1+a_6}{2} \\ 1-2\left(\dfrac{a_6-\xi(R)}{a_6-a_1}\right)^2, & \dfrac{a_1+a_6}{2}<\xi(R)<a_6 \\ 1, & \xi(R)\ge a_6 \end{cases}. \tag{13}$$

The membership function constructed in this way suggests that the resulting value of $\mu_{SR}(R)$ will tend to 1, in the event that the security risks of the tourist trip are minimal.

Thus, the subjectivity of expert opinions is revealed, and a transition is made from unclear expert linguistic and quantitative assessments to standardized and comparable.

Further, according to the received normalized assessment of the safety risk of the tourist trip $\mu_{SR}(R)$ represent the linguistic interpretation of the degree of risk of the safety of the tourist trip, using the following term-set $T_{SR} = \{SR_1; SR_2; SR_3; SR_4; SR_5\}$ as follows:

- $\mu_{SR}(R) \in [0;0.2)$ – $SR_1$: very high degree of safety risk of tourist trip;
- $\mu_{SR}(R) \in [0.2;0.4)$ – $SR_2$: high degree of safety risk of a tourist trip;
- $\mu_{SR}(R) \in [0.4;0.6)$ – $SR_3$: average degree of safety risk of a tourist trip;
- $\mu_{SR}(R) \in [0.6;0.8)$ – $SR_4$: low degree of safety risk of tourist trip;
- $\mu_{SR}(R) \in [0.8;1]$ – $SR_5$: very low degree of safety risk of tourist trip.

The system analyst can change the levels of decision-making by taking into account the real data of the participants of the tourist movement and regional tourism of this or that country.

The presented integrated expert model for risk assessment and ensuring the safety of tourist trips: economic and technological aspects is developed so that it does not depend on the number of risk criteria, groups of criteria, and regions. At the output, a quantitative assessment and the degree of the security risk of tourist trip in the studied region are obtained, which takes into account three stages: the individual sense of security of the region on the part of the tourist, the generalized value of the security risk of the region and the national expert level of security of regional tourism systems.

## 4. Results

The integrated expert model for risk assessment and ensuring the safety of tourist trips has been verified and tested on real data in the countries of the Visegrad Group (Czech Republic, Hungary, Poland, Slovakia) (Data, 2023b). The presented study is a component of a general study of attitudes towards selected areas related to tourism in the V4 countries. For this, a research questionnaire containing 132 questions divided into 16 groups was developed. The data collection procedure was carried out on the basis of the cooperation of several organizations in the period from March to December 2021. As a result, data was obtained from 2,343 respondents of tourism participants who visited regions in the V4 countries for the period from 2017 to 2021. Note that the obtained data meet al. the requirements for forming a sample, and the respondents meet the demographic characteristics regarding the completeness of statistical data. During the research, experiments were conducted based on the entire sample of data, using the developed integrated expert model. To display the results and the possibility of reproducing the model by other researchers, an example of evaluation on data fragments is given.

An example of risk assessment of tourist trip safety is given in four regions from the V4 countries: Banská Bystrica Region (Slovakia), Plzeň Region (Czech Republic), Lesser Poland Voivodeship (Poland), Veszprém county (Hungary).

We will consider an example of evaluation in the form of an integrated expert model in three stages.

*The first stage of the integrated model is the individual level of security of the tourist trip.*

Let the participants of the tourist movement express their attitude according to each evaluation criterion regarding their own safety and harassment at the destination, according to formalized linguistic variables. Then, a set of input linguistic variables is obtained. For example, to illustrate the model, we will present fragments of input data for four experts $e_1(R_1), e_2(R_2), e_3(R_3), e_4(R_4)$ after traveling in 2020, respectively, by region: $R_1$ – Banská Bystrica Region (Slovakia); $R_2$ – Plzeň Region (Czech Republic); $R_3$ – Lesser Poland Voivodeship (Poland); $R_4$ – Veszprém county (Hungary) (Data, 2023b), Table 3.

**Table 3.** Input expert data from respondents $e_1$, $e_2$, $e_3$, $e_4$

| Group criteria | Criteria | Banská Bystrica Region | Plzeň Region | Lesser Poland Voivodeship | Veszprém county |
|---|---|---|---|---|---|
| | | $e_1(R_1)$ | $e_2(R_2)$ | $e_3(R_3)$ | $e_4(R_4)$ |
| $G_1$ | $K_{11}$ | Disagree | Strongly Agree | Disagree | Neither agree nor disagree |
| | $K_{12}$ | Agree | Disagree | Agree | Neither agree nor disagree |
| | $K_{13}$ | Disagree | Strongly disagree | Strongly disagree | Neither agree nor disagree |
| | $K_{14}$ | Strongly disagree | Strongly disagree | Strongly Agree | Neither agree nor disagree |
| | $K_{15}$ | Strongly disagree | Strongly disagree | Disagree | Strongly disagree |
| $G_2$ | $K_{21}$ | Disagree | Strongly disagree | Disagree | Neither agree nor disagree |
| | $K_{22}$ | Agree | Strongly Agree | Agree | Neither agree nor disagree |
| | $K_{23}$ | Disagree | Strongly disagree | Disagree | Neither agree nor disagree |
| | $K_{24}$ | Disagree | Strongly disagree | Neither agree nor disagree | Neither agree nor disagree |
| | $K_{25}$ | Strongly disagree | Strongly disagree | Neither agree nor disagree | Neither agree nor disagree |
| | $K_{26}$ | Disagree | Strongly disagree | Neither agree nor disagree | Neither agree nor disagree |
| | $K_{27}$ | Strongly disagree | Strongly disagree | Neither agree nor disagree | Neither agree nor disagree |
| $G_3$ | $K_{31}$ | Disagree | Strongly disagree | Disagree | Neither agree nor disagree |
| | $K_{32}$ | Disagree | Strongly disagree | Agree | Strongly disagree |
| | $K_{33}$ | Disagree | Strongly disagree | Strongly disagree | Disagree |
| | $K_{34}$ | Disagree | Strongly disagree | Disagree | Disagree |
| | $K_{35}$ | Neither agree nor disagree | Strongly disagree | Agree | Disagree |
| $G_4$ | $K_{41}$ | Strongly disagree | Strongly disagree | Strongly disagree | Strongly disagree |
| | $K_{42}$ | Disagree | Strongly disagree | Strongly disagree | Disagree |
| | $K_{43}$ | Strongly disagree | Strongly disagree | Strongly disagree | Strongly disagree |
| | $K_{44}$ | Strongly disagree | Strongly disagree | Strongly disagree | Strongly disagree |
| | $K_{45}$ | Strongly disagree | Strongly disagree | Strongly disagree | Strongly disagree |

First, a transition is made from the linguistic reasoning of experts for each criterion to one resulting term assessment for groups of risk criteria. Each linguistic variable is assigned a quantitative assessment using the characteristic function (2). Next, within the group of risk criteria is the sum of the values of quantitative estimates according to Equation (3). The characteristic function (4) is used to derive the resulting term estimate by groups of risk criteria. The results are recorded in the Table 4.

**Table 4.** Calculation results from respondents $e_1$, $e_2$, $e_3$, $e_4$

| Group criteria | $e_1(R_1)$ | | $e_2(R_2)$ | | $e_3(R_3)$ | | $e_4(R_4)$ | |
|---|---|---|---|---|---|---|---|---|
| | θ | $T$ | θ | $T$ | θ | $T$ | θ | $T$ |
| $G_1$ | 10 | $t_3$ | 10 | $t_3$ | 14 | $t_3$ | 13 | $t_3$ |
| $G_2$ | 14 | $t_3$ | 11 | $t_2$ | 20 | $t_3$ | 21 | $t_4$ |
| $G_3$ | 11 | $t_3$ | 5 | $t_2$ | 13 | $t_3$ | 10 | $t_3$ |
| $G_4$ | 6 | $t_2$ | 5 | $t_2$ | 5 | $t_2$ | 6 | $t_2$ |

Next, the aggregate risk assessment of one's safety on the tourist trip is determined. To do this, we will use the rules of belonging to derive the risk of one's safety on a tourist trip, which is described in Table 2.

We will formulate these rules of belonging for illustrated experts $e_1(R_1), e_2(R_2), e_3(R_3), e_4(R_4)$:

- $e_1(R_1)$: **If** ($G_1 = t_3$ **and** $G_2 = t_3$ **and** $G_3 = t_3$ **and** $G_4 = t_2$) **Then** $tr^*(e_1) = A$.
- $e_2(R_2)$: **If** ($G_1 = t_3$ **and** $G_2 = t_2$ **and** $G_3 = t_2$ **and** $G_4 = t_2$) **Then** $tr^*(e_2) = H$.
- $e_3(R_3)$: **If** ($G_1 = t_3$ **and** $G_2 = t_3$ **and** $G_3 = t_3$ **and** $G_4 = t_2$) **Then** $tr^*(e_3) = AA$.
- $e_4(R_4)$: **If** ($G_1 = t_3$ **and** $G_2 = t_4$ **and** $G_3 = t_3$ **and** $G_4 = t_2$) **Then** $tr^*(e_4) = A$.

Thus, at the output of the fuzzy model – $M_{RT}$, an aggregated linguistic risk assessment of one's safety of a tourist trip is derived for experts $tr^*(e_1), tr^*(e_2), tr^*(e_3), tr^*(e_4)$ in visited regions.

*The second stage of the integrated model is the regional level of tourist trip security*. At this stage, the data aggregation of the generalized value of the safety risk of the tourist trip and the predicted level of repeated visits to the region is carried out separately for the regions: $R_1$ – Banská Bystrica Region (Slovakia) according to the data of 144 experts; $R_2$ – Plzeň Region (Czech Republic) according to the data of 80 experts; $R_3$ – Lesser Poland Voivodeship (Poland) according to the data of 52 experts; $R_4$ – Veszprém county (Hungary) according to the data of 58 experts.

First of all, one generalized value of the safety risk of tourist trip in the studied regions is calculated. For this, one generalized value of the safety risk of a tourist trip is derived, by entering values according to Equation (6) and using a weighted sum, the Equation (7): $\psi(R_1) = 89.34$; $\psi(R_2) = 48.13$;$\psi(R_3) = 81.06$; $\psi(R_4) = 77.85$.

The obtained values indicate a sense of security in the region. The higher the value, the higher the security risk of the tourist trip and the sense of security in the region decreases.

After that, the quadratic Z-spline membership function is used to compare the data, according to the Equation (8): $m_{ES}(R_1) = 0.142$; $m_{ES}(R_2) = 1$; $m_{ES}(R_3) = 0.449$; $m_{ES}(R_4) = 0.602$.

This membership function changes the directionality of the goal, so when the obtained value approaches 1, then the risk of tourist trip in the studied region is minimal.

Let the researched regions $R_1, R_2, R_3, R_4$ have a predicted level of repeated visits to the region by participants of the tourist movement, which was obtained by the authors in a previous study (Data, 2023a): $m_{RV}\left(R_1\right) = 0.78$; $m_{RV}\left(R_2\right) = 0.82$; $m_{RV}\left(R_3\right) = 0.79$; $m_{RV}\left(R_4\right) = 0.45$.

The obtained value has the following meaning: the greater the $m_{RV}\left(R\right)$, the greater the desire of tourists to visit the region again.

Next, to obtain the level of a sense of security in the region on the part of the participants of the tourist movement, it is proposed to use the intellectual analysis of knowledge based on the cone-shaped function of belonging, according to the Eqution (9): $\mu_{ES}\left(R_1\right) = 0.557$; $\mu_{ES}\left(R_2\right) = 0.91$; $\mu_{ES}\left(R_3\right) = 0.705$; $\mu_{ES}\left(R_4\right) = 0.661$.

*The third stage of the integrated model is the national level of tourist trip security*.

At this stage, a quantitative assessment and the degree of risk of the security of the tourist trip are derived, taking into account the level of the sense of security of the region on the part of the participants of the tourist movement $\mu_{ES}\left(R\right)$ and the expert level of security of regional tourist systems $\Delta_{ST}$.

Let the DM for each region have its own considerations regarding the security value of regional tourism systems:

- $\Delta_4\left(R_1\right)$ = {The security level of regional tourism systems is above average};
- $\Delta_5\left(R_2\right)$ = {High level of security of regional tourism systems};
- $\Delta_4\left(R_3\right)$ = {The security level of regional tourism systems is above average};
- $\Delta_4\left(R_4\right)$ = {The security level of regional tourism systems is above average}.

First, the fuzzification operation of the input hybrid data is performed.

Let the term-set of linguistic variables $\Delta_{ST} = \left\{\Delta_1; \Delta_2; \Delta_3; \Delta_4; \Delta_5\right\}$ be represented on some numerical interval $\left[0;100\right]$, to delimit the terms: $\Delta_1 \in \left[0;20\right]$, $\Delta_2 \in \left[20;40\right]$, $\Delta_3 \in \left[40;60\right]$, $\Delta_4 \in \left[60;80\right]$, $\Delta_5 \in \left[80;100\right]$. The values of the breakdown of the intervals were adjusted to the real data of the functioning of regional tourism.

Further, with the help of the characteristic function (12), the values of ξ, are calculated, which makes it possible to combine quantitative estimates and opinions of the DM: $\xi(R_1)$ = 44.57; $\xi(R_2)$ = 91; $\xi(R_3)$ = 56.4; $\xi(R_4)$ = 52.83.

After that, an S-shaped membership function is used to interpret the dependence and compare the data (13): $\mu_{SR}\left(R_1\right) = 0.397$; $\mu_{SR}\left(R_2\right) = 0.984$; $\mu_{SR}\left(R_3\right) = 0.62$; $\mu_{SR}\left(R_4\right) = 0.555$.

According to the received normalized assessment of the safety risk of a tourist trip $\mu_{SR}\left(R\right)$ a linguistic interpretation of the degree of safety risk of a tourist trip is presented:

- $R_1$ (Banská Bystrica Region (Slovakia)): $\mu_{SR}\left(R_1\right) = 0.397 \in \left[0.2;0.4\right)$ – $SR_2$: high degree of safety risk of a tourist trip;
- $R_2$ (Plzeň Region (Czech Republic)): $\mu_{SR}\left(R_2\right) = 0.984 \in \left[0.8;1\right]$ – $SR_5$: very low degree of safety risk of tourist trip;
- $R_3$ (Lesser Poland Voivodeship (Poland)): $\mu_{SR}\left(R_3\right) = 0.62 \in \left[0.6;0.8\right)$ – $SR_4$: low degree of safety risk of tourist trip;
- $R_4$ (Veszprém county (Hungary)): $\mu_{SR}\left(R_4\right) = 0.555 \in \left[0.4;0.6\right)$ – $SR_3$: average degree of safety risk of a tourist trip.

Thus, for the studied regions for the period from 2017 to 2021, a quantitative assessment and the degree of risk of tourist trip safety were obtained for the analysis of the region and support for further decision-making.

## 5. Discussion

The perceived risk in the target destination is considered one of the most important factors influencing the tourists' decision-making processes. From a managerial point of view, the perception evaluation of the security risks for tourists is very important, because it is not enough to only provide the increasingly high-quality services in order to survive in the competitive markets (Muñoz-Mazón et al., 2021), but also to know the perceived feelings of tourists' security and protection. The persistent negative perceptions of the security risks by tourists causes a high fluctuation of customers and a market share and own competitiveness decrease (Oshriyeh et al., 2022; Škare et al., 2021). The regular risk assessment in the tourism industry gives managers a strong potential to construct and to apply the risk minimisation strategies and thus, to create a positive image of their offers in the tourism industry (Roy et al., 2019). Therefore, it is necessary to systematically create and to assess the integrated relationship between risk, tourist satisfaction, tourist attitudes, and repeat visit intentions that helps to create a competitive advantage (Dzemydienė & Ragab, 2020). Assessment of influence of management transformations and risk for tourism business (Saura et al., 2023). The missing knowledge about the security risks for tourists associated with the particular tourist destination prevents the construction of the integrated conceptual frameworks and their empirical validation that results in an insufficient development of the concepts, methods, and systems for managing the tourist risks (Guaita Martinez et al., 2023).

In the work, an integrated expert model was developed, which, based on the attitude of the participants of the tourist movement regarding their safety and harassment at the destination, the predicted level of repeated visits to the region, and the expert level of safety of regional tourism systems, derives a quantitative assessment and the degree of risk of the safety of tourist trips. For this purpose, the following information model for assessing the safety level of tourist trip has been developed; a fuzzy method for determining the aggregated term risk assessment of one's safety of a tourist trip; an expert method of assessing the level of the sense of security of the region on the part of the participants of the tourist movement; a hybrid method of assessing the degree of risk to the safety of a tourist trip; the developed integrated expert model was verified on real data in the regions of the V4 countries; an example of evaluation on data fragments of four regions from V4 countries are illustrated: Banská Bystrica Region (Slovakia) 144 experts, Plzeň Region (Czech Republic) 80 experts, Lesser Poland Voivodeship (Poland) 52 experts, Veszprém county (Hungary) 58 experts.

The research is based on innovative methods and techniques for obtaining and presenting knowledge, which is formalized using the theory of fuzzy sets and fuzzy logic. The choice of such a mathematical tool makes it possible to increase the degree of validity of the final management decisions. The value of the expert model lies in the fact that it considers the issue of assessing the safety risks of tourist trip in a complex manner, from individual, regional to national levels. At the same time, it takes into account expert assessments of one's safety and harassment at the destination, the predicted level of repeated visits to the region (based on the satisfaction of tourists as subjects of consumer behavior from visiting the region), and the expert level of security of regional tourism systems. Another important aspect of this study is that all model settings are tested and verified on real data. At the output of the model, we have a quantitative assessment and the degree of risk to the safety of the tourist trip. This allows an integrated analysis of the region to support decision-making, from the point of view of the safety of tourist trip, for all interested parties, such as tourists, businesses, and public authorities.

The main goal of the conducted research is to develop an integrated expert model for risk assessment and ensuring the safety of tourist trips: economic and technological aspects, using the example of the countries of the Visegrad Group (Czech Republic, Hungary, Poland, Slovakia). At the same time, the following scientific results were obtained:

- for the first time, an information model for assessing the safety level of tourist trips was developed, which consists of 22 criteria for assessing one's safety and harassment at the destination, divided into 4 groups of risk criteria, namely: the group of safety risks of the infrastructure of the place of visit; a group of risks of social and environmental safety of tourism; a group of tourism health safety risks; harassment risk group at the place of a visit;
- for the first time, a fuzzy method for determining the aggregated term risk assessment of one's safety on a tourist trip was developed. The input data are linguistic variables regarding the impression of the participants of the tourist movement after visiting the region, concern for their safety, and harassment at the destination. The method uses the principles of fuzzy logic. Based on the formulated rules of belonging, embodied in the knowledge base, an aggregated linguistic assessment of the risk to one's safety of a tourist trip for an expert in the visited region is derived. This method represents the first stage of a complex model – an individual level of safety of a tourist trip;
- for the first time, an expert method of assessing the level of the sense of security of the region on the part of the participants of the tourist movement was developed. The method is aimed at calculations within the region. Its peculiarity is that it aggregates data on the generalized value of the safety risk of a tourist trip and the predicted level of repeated visits to the region. The method uses methods of obtaining and presenting knowledge based on the intellectual analysis of knowledge of multidimensional membership functions. Based on real data, the verification of the settings of the membership functions was carried out. The obtained initial value is compared and normalized, and also characterizes the level of the sense of security of the region on the part of the participants of the tourist movement. This method describes the second stage of the complex expert model – the regional level of tourist travel safety;
- for the first time, a hybrid method of assessing the degree of risk to the safety of a tourist trip was developed. The hybridity consists of the fact that the expert level of security of regional tourism systems obtained from DM is combined with the level of the sense of security of the region on the part of the participants of the tourist movement. The model reveals the subjectivity of expert opinions and transitions from vague expert linguistic and quantitative assessments to standardized and comparable ones. At

the output, a quantitative assessment and the degree of risk of tourist travel safety in the studied region are obtained. This method describes the third stage of the complex model – the national level of tourist travel safety;

- the integrated expert model for risk assessment and ensuring the safety of tourist trips: economic and technological aspects was verified and tested on real data from 2,343 respondents in the countries of the Visegrad Group. An example of assessing the degree of safety risk of tourist travel in the region is illustrated on fragments of data from a population of 334 experts in four regions: Banská Bystrica Region (Slovakia), Plzeň Region (Czech Republic), Lesser Poland Voivodeship (Poland), Veszprém county (Hungary).

The advantages of the integrated expert model stem from the fact that: the model does not depend on the number of risk criteria, groups of criteria and regions, and therefore it is possible to investigate various aspects that influence the worries and concerns of the participants of the tourist movement regarding their own safety and harassment at the destination; the model uses knowledge representation techniques, which makes it possible to adjust decision-making rules to build a knowledge base; the model derives an aggregated term assessment of the risk of the tourist's own safety during the tourist trip; takes into account the expert level of security of regional tourism systems and the desire of tourists to visit the region again; the expert model, using fuzzy logic, reveals the uncertainty of the input expert assessments, moves from considerations about one's own safety and harassment at the destination to an aggregated risk assessment of one's own safety of the tourist trip; the expert model was adjusted on real data.

A limitation of our study was the use of different types of characteristic functions and membership functions of one and many variables, as well as their set parameters. The construction of rules of belonging for the formation of the knowledge base of the risk to one's safety on a tourist trip depends on the competencies of system analysts. It is necessary to expand the geography of the research in other countries and make a wider sample of the research questionnaire to have the opportunity to obtain new knowledge on the problems of regional tourism and to train the model for more accurate results. However, these limitations do not affect the obtained results.

The rationality of the obtained degree of safety risk of a tourist trip contributes to the development of regional tourism and proves the advantages of the developed model. The reliability of the obtained results is ensured by the justified use of the mathematical apparatus. The obtained research results confirm the scientific and applied value of the analysis, which fully proves the validity of the formulated scientific hypothesis.

## 6. Conclusions

The primary objective of this research was to devise a fuzzy model for evaluating the extent of disinformation spread on digital platforms, considering the QoL of residents. In achieving this goal, several significant scientific advancements were made: the development of an innovative information model for assessing residents' QoL; the creation of a novel model for evaluating current disinformation narratives on digital platforms; and the pioneering development of a fuzzy model for determining the level of disinformation spread on these platforms.

This fuzzy estimation model was rigorously tested and verified using real data from 3,036 respondents. An illustrative example of the application of this fuzzy model on selected data sets was provided to demonstrate its practical effectiveness.

The developed fuzzy model holds substantial potential for policymakers, strategic development planners, and experts in sustainable development, as well as those specializing in conceptual processes and methodologies related to QoL and UQoL. Additionally, the study's findings are invaluable for a diverse array of experts, including social media specialists, by informing methodologies aimed at mitigating disinformation processes and bolstering information security. This research supports the development of monitoring and regulatory mechanisms and contributes to the construction of information and media literacy systems. It also aids in establishing benchmarking indicators for economically quantifying the impact of disinformation processes on society. These insights are vital for ensuring sustainable economic development and the formulation of effective political, economic, technological, and innovation strategies.

Looking ahead, the authors plan to develop innovative software to facilitate feedback collection from respondents and enable the practical application of this research for various decision-makers. Furthermore, addressing the challenge of accurately gauging the quantitative levels of disinformation perception among residents and its spread through digital platforms, the research will incorporate artificial intelligence technology and machine learning methods.

Further research of the problem can be seen in the development of other expert and vague models for assessing the level of tourism in selected regions. Development of new methods of obtaining and presenting knowledge for the development of regional tourism. In total, current and future research will make up information technology for decision support in the tourism business, market research, and economics. For the practical and widespread use of the developed expert systems, web-oriented software will be designed for use by both business and state authorities.

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## Author contributions

Beata Gavurova: conceptualization, formal analysis, methodology, data curation, writing – original draft, writing – review & editing, validation, visualization. Volodymyr Polishchuk: formal analysis, data curation, methodology, software, validation.

## Disclosure statement

Beata Gavurova declares she has no conflict of interest. Volodymyr Polishchuk declares he has no conflict of interest.

## References

Agarwal, S., Page, S. J., & Mawby, R. (2021). Tourist security, terrorism risk management and tourist safety. *Annals of Tourism Research*, *89*, Article 103207. https://doi.org/10.1016/j.annals.2021.103207

Aliperti, G., & Cruz, A. M. (2019). Investigating tourists' risk information processing. *Annals of Tourism Research*, *79*, Article 102803. https://doi.org/10.1016/j.annals.2019.102803

Balli, F., Uddin, G. S., & Shahzad, S. J. H. (2019). Geopolitical risk and tourism demand in emerging economies. *Tourism Economics*, *25*(6), 997–1005. https://doi.org/10.1177/1354816619831824

Caber, M., González-Rodríguez, M. R., Albayrak, T., & Simonetti, B. (2020). Does perceived risk really matter in travel behaviour? *Journal of Vacation Marketing*, *26*(3), 334–353. https://doi.org/10.1177/1356766720927762

Carballo, R. R., León, C. J., & Carballo, M. M. (2017). The perception of risk by international travellers. *Worldwide Hospitality and Tourism Themes*, *9*(5), 534–542. https://doi.org/10.1108/whatt-07-2017-0032

Cui, F., Liu, Y., Chang, Y., Duan, J., & Li, J. (2016). An overview of tourism risk perception. *Natural Hazards*, *82*, 643–658. https://doi.org/10.1007/s11069-016-2208-1

Data. (2023a). *Data from 2,343 participants of the tourist movement to evaluate the predicted behavior of tourist movement participants in relation to repeated visits to the region in the countries Visegrad Group*. Retreived February 10, 2023, from https://docs.google.com/spreadsheets/d/1U6cqQvCj04XiZ-P_4m3pq-OL1BWnbBPIj/edit?usp=share_link&ouid=111497346858387909549&rtpof=true&sd=true

Data. (2023b). *Data from 2,343 participants of the tourist movement to assess the safety risks of tourist trips in the countries of the Visegrad Group*. Retreived December 01, 2024, from https://docs.google.com/spreadsheets/d/1cYMepE-VtOWSRzNKbOAkDkGpMaBgQ60R/edit?usp=sharing&ouid=111497346858387909549&rtpof=true&sd=true

Dávila-Lamas, A. D., Carbajal-Hernández, J. J., Sánchez-Fernández, L. P., Niebla-Zatarain, V. B., & Hoil-Rosas, C. A. (2022). Assessment of coastal locations safety using a fuzzy analytical hierarchy process-based model. *Sustainability*, *14*(10), Article 5972. https://doi.org/10.3390/su14105972

Dzemydienė, D., & Ragab, M. H. E. A. (2020, May 7–8). Assessment of influence of management transformations and risk for tourism business. In *Proceedings of the 11th International Scientific Conference "Business and Management 2020"* (pp. 1–7). Vilnius, Lithuania. VILNIUS TECH. https://doi.org/10.3846/bm.2020.668

Faraji Sabokbar, H., Ayashi, A., Hosseini, A., Banaitis, A., Banaitienė, N., & Ayashi, R. (2016). Risk assessment in tourism system using a fuzzy set and dominance-based rough set. *Technological and Economic Development of Economy*, *22*(4), 554–573. https://doi.org/10.3846/20294913.2016.1198840

Fletcher, J., & Morakabati, Y. (2008). Tourism activity, terrorism and political instability within the Commonwealth: The cases of Fiji and Kenya. *International Journal of Tourism Research*, *10*(6), 537–556. https://doi.org/10.1002/jtr.699

Fu, H.-H., & Tzeng, S.-Y. (2016). Applying fuzzy multiple criteria decision making approach to establish safety-management system for hot spring hotels. *Asia Pacific Journal of Tourism Research*, *21*(12), 1343–1356. https://doi.org/10.1080/10941665.2016.1175487

Garg, A. (2015). Travel risks vs tourist decision making: A tourist perspective. *International Journal of Hospitality* & *Tourism Systems*, *8*(1), 1–9. https://doi.org/10.21863/ijhts/2015.8.1.004

Ghosh, B. K., & Batabyal, D. (2022). Risk perception and travel behavior of urban residents in a densely populated region of East India amidst (COVID-19) pandemic. *Tourism Culture* & *Communication*, *23*(2–3), 193–205. https://doi.org/10.3727/109830422x16600594683364

Golets, A., Farias, J., Pilati, R. Costa, H. (2023). COVID-19 pandemic and tourism: The impact of health risk perception and intolerance of uncertainty on travel intentions. *Current Psychology*, *42*, 2500–2513. https://doi.org/10.1007/s12144-021-02282-6

Guaita Martinez, J. M., Martín Martín, J. M., Salinas Fernandez, J. A., & Ribeiro Soriano, D. E. (2023). Tourist accommodation, consumption and platforms. *International Journal of Consumer Studies*, *47*(3), 1011–1022. https://doi.org/10.1111/ijcs.12881

Guo, W. (2021). Safety risk assessment of tourism management system based on PSO-BP neural network. *Computational Intelligence and Neuroscience*, 1, Article 1980037. https://doi.org/10.1155/2021/1980037 (Retraction published 2023, *Computational Intelligence and Neuroscience*, 9828753)

Hajibaba, H., Boztug, Y. & Dolnicar, S. (2016). Preventing tourists from canceling in times of crises. *Annals of Tourism Research*, *60*, 48–62. https://doi.org/10.1016/j.annals.2016.06.003

Hasan, M. K., Ismail, A. R., & Islam, M. F. (2017). Tourist risk perceptions and revisit intention: A critical review of literature. *Cogent Business & Management*, *4*(1), Article 1412874. https://doi.org/10.1080/23311975.2017.1412874

Hsu, T.-H., & Lin, L.-Z. (2006). Using fuzzy set theoretic techniques to analyze travel risk: An empirical study. *Tourism Management*, *27*(5), 968–981. https://doi.org/10.1016/j.tourman.2005.10.022

Hosseini, A., Pourahmad, A., Ayashi, A., Tzeng, G.-H., Banaitis, A., & Pourahmad, A. (2021). Improving the urban heritage based on a tourism risk assessment using a hybrid fuzzy MADM method: The case study of Tehran's central district. *Journal of Multi-Criteria Decision Analysis*, *28*(5–6), 248–268. https://doi.org/10.1002/mcda.1746

Chien, P. M., Sharifpour, M., Ritchie, B. W., & Watson, B. (2017). Travelers' health risk perceptions and protective behavior: A psychological approach. *Journal of Travel Research*, *56*(6), 744–759. https://doi.org/10.1177/0047287516665479

Kanga, S., Sharma, L. K., Pandey, P. C., Nathawat, M. S., & Sharma, S. K. (2013). Forest fire modeling to evaluate potential hazard to tourism sites using geospatial approach. *Journal of Geomatics*, *7*(1), 93–99.

Karl, M. (2018). Risk and uncertainty in travel decision-making: Tourist and destination perspective. *Journal of Travel Research*, *57*(1), 129–146. https://doi.org/10.1177/0047287516678337

Karl, M., & Schmude, J. (2017). Understanding the role of risk (perception) in destination choice: A literature review and synthesis. *Tourism*: *An International Interdisciplinary Journal*, *65*(2), 138–155.

Lee, C.-C., Olasehinde-Williams, G., & Akadiri, S. S. (2021). Geopolitical risk and tourism: Evidence from dynamic heterogeneous panel models. *International Journal of Tourism Research*, *23*(1), 26–38. https://doi.org/10.1002/jtr.2389

Lin, L.-Z., & Hsu, T.-H. (2013). The analysis of risk perception with fuzzy means-end approach. *Quality & Quantity*, *47*, 713–734. https://doi.org/10.1007/s11135-011-9540-z

Muñoz-Mazón, A., Orea-Giner, A., Fernandez Munoz, J. J., Santiago, C., & Fuentes-Moraleda, L. (2021). Risk perception before travelling: Solutions for consumers with vulnerabilities. *Journal of Services Marketing*, *35*(6), 791–806.

Nagaj, R., & Žuromskaitė, B. (2020). Security measures as a factor in the competitiveness of accommodation facilities. *Journal of Risk and Financial Management*, *13*(5), Article 99. https://doi.org/10.3390/jrfm13050099

Oshriyeh, O., Ghaffari, M., & Nematpour, M. (2022). Lines in the sand: The perceived risks of traveling to a destination and its influence on tourist information seeking behavior. *International Journal of Tourism Cities*, *8*(4), 965–982. https://doi.org/10.1108/ijtc-07-2021-0138

Osland, G. E., Mackoy, R., & McCormick, M. (2017). Perceptions of personal risk in tourists' destination choices: Nature tours in Mexico. *European Journal of Tourism*, *Hospitality and Recreation*, *8*(1), 38–50. https://doi.org/10.1515/ejthr-2017-0002

Paudel, B., & Hossain, M. A. (2006). Fuzzy based decision support system for e-tourism investment risk analysis. *DVD Journal*, Article 13147378.

Roy, J., Sharma, K. H., Kar, S., Zavadskas, E. K., & Šaparauskas, J. (2019). An extended COPRAS model for multi-criteria decision-making problems and its application in web-based hotel evaluation and selection. *Economic Research – Ekonomska Istraživanja*, *32*(1), 219–253. https://doi.org/10.1080/1331677x.2018.1543054

Quan, L., Al-Ansi, A., & Han, H. (2022). Assessing customer financial risk perception and attitude in the hotel industry: Exploring the role of protective measures against COVID-19. *International Journal of Hospitality Management*, *101*, Article 103123. https://doi.org/10.1016/j.ijhm.2021.103123

Ranjan Debata, B., Sree, K., Patnaik, B., & Sankar Mahapatra, S. (2013). Evaluating medical tourism enablers with interpretive structural modeling. *Benchmarking*: *An International Journal*, *20*(6), 716–743. https://doi.org/10.1108/BIJ-10-2011-0079

Reisinger, Y., & Mavondo, F. (2005). Travel anxiety and intentions to travel internationally: Implications of travel risk perception. *Journal of Travel Research*, *43*(3), 212–225. https://doi.org/10.1177/0047287504272017

Saura, J. R., Palacios-Marques, D., & Ribeiro-Soriano, D. (2023). Online visitor's reviews and their influence on sustainable tourism businesses: An applied analysis of user – generated content. *Transformations in Business* & *Economics*, *22*(2), 124–143.

Seabra, C., Dolnicar, S., Abrantes, J. L., & Kastenholz, E. (2013). Heterogeneity in risk and safety perceptions of international tourists. *Tourism Management*, *36*, 502–510. https://doi.org/10.1016/j.tourman.2012.09.008

Sharifpour, M., Walters, G., Ritchie, B. W., & Winter, C. (2014). Investigating the role of prior knowledge in tourist decision making: A structural equation model of risk perceptions and information search. *Journal of Travel Research*, *53*(3), 307–322. https://doi.org/10.1177/0047287513500390

Simpson, P. M., & Siguaw, J. A. (2008). Perceived travel risks: The traveller perspective and manageability. *International Journal of Tourism Research*, *10*(4), 315–327. https://doi.org/10.1002/jtr.664

Sohn, H.-K., Lee, T. J., & Yoon, Y.-S. (2016). Relationship between perceived risk, evaluation, satisfaction, and behavioral intention: A case of local-festival visitors. *Journal of Travel* & *Tourism Marketing*, *33*(1), 28–45. https://doi.org/10.1080/10548408.2015.1024912

Šagovnović, I., & Kovačić, S. (2021). Influence of tourists' sociodemographic characteristics on their perception of destination personality and emotional experience of a city break destination. *International Journal of Tourism Cities*, *7*(1), 200–223. https://doi.org/10.1108/ijtc-05-2020-0105

Škare, M., Soriano, D. R., & Porada-Rochoń, M. (2021). Impact of COVID-19 on the travel and tourism industry. *Technological Forecasting and Social Change*, *163*, Article 120469. https://doi.org/10.1016/j.techfore.2020.120469

Tasci, A. D. A., & Boylu, Y. (2010). Cultural comparison of tourists' safety perception in relation to trip satisfaction. *International Journal of Tourism Research*, *12*(2), 179–192. https://doi.org/10.1002/jtr.745

Vena-Oya, J., Castañeda-García, J. A., & Rodríguez-Molina, M. Á. (2022). Forecasting a post-COVID-19 economic crisis using fuzzy cognitive maps: A Spanish tourism-sector perspective. *Current Issues in Tourism*, *25*(13), 2048–2062. https://doi.org/10.1080/13683500.2021.1944995

Villacé-Molinero, T., Fernández-Muñoz, J. J., Orea-Giner, A., & Fuentes-Moraleda, L. (2021). Understanding the new post-COVID-19 risk scenario: Outlooks and challenges for a new era of tourism. *Tourism Management*, *86*, Article 104324. https://doi.org/10.1016/j.tourman.2021.104324

Wang, J., & Karl, M. (2021). Understanding how tourists perceive and respond to risk: A focus on health risk. In J. Wilks, D. Pendergast, P. A. Leggat, & D. Morgan, (Eds.), *Tourist health*, *safety and wellbeing in the new normal* (pp. 347–371). Springer. https://doi.org/10.1007/978-981-16-5415-2_14

Weifeng, T. (2005). Risks perceived by Mainland Chinese tourists towards Southeast Asia destinations: A fuzzy logic model. *Asia Pacific Journal of Tourism Research*, *10*(1), 97–115. https://doi.org/10.1080/1094166042000330245

Williams, A. M., & Baláž, V. (2013). Tourism, risk tolerance and competences: Travel organization and tourism hazards. *Tourism Management*, *35*, 209–221. https://doi.org/10.1016/j.tourman.2012.07.006

Wu, L., Gao, H., & Wei, C. (2019). VIKOR method for financing risk assessment of rural tourism projects under interval-valued intuitionistic fuzzy environment. *Journal of Intelligent* & *Fuzzy Systems*, *37*(2), 2001–2008. https://doi.org/10.3233/jifs-179262 (Retraction published 2025, *Journal of Intelligent* & *Fuzzy Systems*, 48[3], 377–409)

Yeung, R. M. W., & Yee, W. M. S. (2013). Risk measurement framework: An extension and validation of food safety risk in international travel destinations. *British Food Journal*, *115*(8), 1073–1089. https://doi.org/10.1108/bfj-03-2011-0071

Yang, E., & Nair, V. (2014). Tourism at risk: A review of risk and perceived risk in tourism. *Asia-Pacific Journal of Innovation in Hospitality Tourism*, *3*, Article 13. https://doi.org/10.7603/s40930-014-0013-z

Ying, H., Chengcai, T., & Rui, Z. (2022). Review of tourism ecological security from the perspective of ecological civilization construction. *Journal of Resources and Ecology*, *13*(4), 734–745. https://doi.org/10.5814/j.issn.1674-764x.2022.04.018

Zhu, J., Wang, H., & Xu, B. (2021). Using fuzzy AHP-PROMETHEE for market risk assessment of new-build river cruises on the Yangtze river. *Sustainability*, *13*(22), Article 12932. https://doi.org/10.3390/su132212932

Zou, Y., & Yu, Q. (2022). Sense of safety toward tourism destinations: A social constructivist perspective. *Journal of Destination Marketing* & *Management*, *24*, Article 100708. https://doi.org/10.1016/j.jdmm.2022.100708