

Destination social environment and tourist loyalty: A fuzzy expert model for the Visegrad countries

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Abstract. This study develops an expert model for evaluating how the external social environment shapes destination loyalty in the Visegrad Group countries (Czech Republic, Hungary, Poland, and Slovakia). The model formalises tourists' expected and experienced positive and negative encounters with residents and tourism personnel and converts them into destination- and region-level loyalty assessments. A three-stage architecture combines Boolean algebra, fuzzy-set theory, fuzzy logic, knowledge-based aggregation, and multiple regression analysis. The empirical basis comprises 2,343 respondents who evaluated destinations visited in the V4 countries. First, the model derives normalised individual and destination assessments; then, it aggregates them at the regional level; and finally, it generates predicted loyalty scores for defined socioeconomic visitor profiles. An application to the Nitra, Moravian-Silesian, and Podkarpackie regions demonstrates substantial destination-level heterogeneity despite all three regional aggregates falling within the above-average category. Segment-specific predictions further show that aggregate regional rankings do not necessarily represent the evaluation of a particular visitor group. The model provides an interpretable decision-support instrument for destination management, market segmentation, service improvement, and scenario-based regional tourism policy. Formal re-estimation of the three illustrative regional regressions used 53, 46, and 43 complete cases; residual diagnostics motivated robust standard errors and

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bootstrap uncertainty intervals, while the Kruskal–Wallis comparison did not support statistically significant regional differences.

Keywords: destination loyalty, social environment, fuzzy expert model, socioeconomic segmentation, Visegrad countries

JEL Classification: Z33, Z38, O57

1. INTRODUCTION

To increase the number of tourists in the region, it is necessary to rise the value proposition of the tourism business for consumers and make smart decisions, both for business and for the government. One such element in the management of the tourism industry is the understanding of the loyalty of the social environment in the destination. The study is aimed at managing knowledge about the influence of the external social environment on the formation of loyalty in destinations and regions. The expert evaluation, which is the basis of this study, is based on the experience of the participants of the tourist movement, their impressions, and feedback from the destination. Reviews are a source of knowledge for businesses seeking to improve their value proposition for consumers. Knowledge about the loyalty of the social environment in the destination will allow you to make proactive decisions to increase the image of the location and improve the quality of service provision, which affects the desire of tourists to visit again. Destination loyalty is usually expressed through intentions to revisit and recommend a place, but these intentions are not formed solely by attractions, infrastructure, or price. Encounters with local residents, guides, sellers, and service personnel shape perceived hospitality, fairness, trust, safety, and the emotional meaning of a trip. Previous research links destination image and satisfaction to loyalty (Chi & Qu, 2008; Zhang et al., 2014). Meanwhile, studies of emotional solidarity and resident-tourist interaction show that feeling welcomed and experiencing high-quality social contact can strengthen satisfaction and loyalty (Ribeiro et al., 2018; Styliadis et al., 2022). However, existing models rarely distinguish expected from experienced positive and negative social encounters, aggregate these evaluations from the destination to the regional level, and generate predictions for specific socioeconomic visitor profiles within one transparent decision-support architecture. The main goal of the conducted research is to develop an expert model for assessing the influence of the external social environment on the formation of loyalty to the destination, using the example of the countries of the Visegrad Group (Czech Republic, Hungary, Poland, Slovakia).

2. LITERATURE REVIEW

2.1. Destination loyalty

Destination loyalty is a central outcome in tourism research because it links visitors' evaluations of a place to future market behaviour. It is commonly conceptualised through behavioural intentions, especially revisit intention and positive word of mouth, while broader approaches also include attitudinal preference and commitment. Structural models consistently identify destination image, perceived value, service quality, and satisfaction as major antecedents of loyalty (Yoon & Uysal, 2005; Chi & Qu, 2008; Kim et al., 2013). A meta-analysis of 66 independent studies confirmed that destination image has a significant relationship with loyalty, although the strength of the association depends on whether image and loyalty are measured cognitively, affectively, behaviourally, or as composite constructs (Zhang et al., 2014). More recent meta-analytic evidence similarly supports a sequential cognitive-affective-conative process in which destination evaluations shape satisfaction and subsequent loyalty (Jangam, 2026).

These findings imply that loyalty is not produced by one isolated attribute. Rather, tourists form an integrated judgement from functional conditions, emotional responses, value assessments, and relational experiences. Therefore, the destination is not only a bundle of attractions and services but also a social setting in which visitors interpret the conduct of residents and tourism workers. Service fairness and trust in destination providers can influence satisfaction and loyalty alongside image and service quality (Su et al., 2017; Bilan et al., 2023). Likewise, emotional experiences embedded in community interactions can affect subjective well-being, satisfaction, and loyalty (Bacik et al., 2025; Li et al., 2024). This broader interpretation provides the basis for treating the external social environment as a distinct source of destination value.

2.2. Host-guest social environment

In this study, the external social environment represents the interpersonal conditions visitors encounter beyond their immediate travel group. It encompasses the honesty, hospitality, communication skills, and helpfulness of local residents, vendors, tour guides, travel agents, and frontline service staff. These factors dictate whether tourists feel welcome, respected, secure, and capable of forming meaningful connections with the host community. This notion aligns closely with emotional solidarity, which captures the affective ties formed between locals and visitors through feeling welcomed, mutual sympathy, and emotional closeness (Woosnam & Norman, 2010).

Empirical studies strongly reinforce the significance of these interpersonal dynamics. Ribeiro et al. (2018) demonstrated that feeling welcomed and experiencing sympathetic understanding directly influence destination loyalty, with satisfaction acting as a mediator for several emotional-solidarity dimensions. Even during the heightened uncertainty of the COVID-19 pandemic, all facets of emotional solidarity remained significant predictors of loyalty (Woosnam et al., 2021; Dias et al., 2023; Lewicki & Florek, 2024). Furthermore, segmenting tourists according to emotional solidarity has uncovered distinct visitor groups with widely varying destination perceptions and loyalty intentions (Stylidis et al., 2020). Higher interaction quality with residents has also been shown to enhance destination image, indirectly boosting satisfaction and subsequent loyalty (Stylidis et al., 2022; Rehabi et al., 2026). Finally, emotional solidarity works in tandem with place attachment and perceived safety, demonstrating that the social environment forms an integral part of a broader framework of cognitive and affective destination assessments (Patwardhan et al., 2020). The community side of this relationship also matters: in a study of Komodo National Park in Indonesia, community attachment and perceived economic gain shaped stakeholder perceptions of a tourism development project, and these perceptions in turn mediated support for it (Choirisa et al., 2021).

The distinction between positive and negative social experiences is particularly important. Honest behaviour, warm hospitality, and competent communication can confirm that the destination is reliable and welcoming. Instead, dishonesty, hostility, or poor social skills can undermine trust and create a negative destination narrative that extends beyond the specific encounter. Therefore, the influence of interpersonal incidents may be nonlinear: one highly negative interaction can have a disproportionate effect on overall evaluation, whereas repeated positive encounters may gradually consolidate confidence and attachment. A decision model should preserve this asymmetry rather than reduce all experiences to an undifferentiated mean.

2.3. Expectations and social profiles

Expectation-disconfirmation theory explains how visitors evaluate experienced conditions against pre-trip reference standards. Satisfaction increases when performance confirms or exceeds expectations and decreases when performance falls below them (Oliver, 1980). In destination research, disconfirmation has been shown to predict overall satisfaction, particularly when tourists are separated into meaningful market

segments (Pizam & Milman, 1993; Puciato et al., 2023). The framework is directly relevant to social encounters: an expected positive interaction that does not materialise can generate disappointment, while an anticipated negative condition that is absent can improve evaluation. Therefore, separating expected and actual positive and negative aspects captures more information than a single post-visit satisfaction item.

Tourists are also heterogeneous in the resources, constraints, and interpretive frames they bring to travel. Income, education, employment status, age, and household circumstances influence participation in tourism and the intensity of consumption (Alegre et al., 2009; Markiewicz-Patkowska et al., 2024). At the same time, demographic effects on loyalty are not necessarily uniform. Chi (2011) found differences in some image perceptions across gender and education groups but a broadly similar loyalty-formation process across demographic segments. This suggests that socioeconomic characteristics should not be assumed to determine loyalty mechanically; instead, they may alter the expected level, sensitivity, or practical meaning of destination attributes. Evidence from urban tourism mobility points the same way: tourists' preferences and willingness to pay for service attributes vary across demographic segments (Vovk et al., 2024). In this study, 'social class' is therefore operationalised as a socioeconomic visitor profile combining age, employment status, marital status, education, and income rather than as a fixed sociological category. This operationalisation follows earlier V4 research showing the usefulness of fuzzy modelling for estimating tourism satisfaction across socioeconomic profiles (Skare et al., 2023).

2.4. Fuzzy decision support

Visitors express their assessments using subjective, partially overlapping descriptions such as friendly, honest, hospitable, disappointing, or loyal. Because these concepts lack rigid boundaries, different respondents often interpret and apply the same descriptor with varying degrees of intensity. Fuzzy-set theory is particularly well suited to this setting, as it accommodates gradual degrees of membership and translates imprecise feedback without enforcing artificial binary boundaries (Zadeh, 1965). Prior research has leveraged fuzzy logic to assess individual guest loyalty by integrating empirical metrics with expert insights (Lau et al., 2015), and hybrid fuzzy-structural methods have been deployed to evaluate complex combinations of factors driving destination loyalty (Wu, 2016). Systematic reviews of fuzzy-set methodologies in tourism highlight their growing adoption to handle causal complexity, non-linear relationships, and asymmetric conditions that traditional linear models often miss (Geremew et al., 2024). The architecture presented here blends complementary analytical techniques: Boolean logic differentiates anticipated versus realized positive and negative experiences; fuzzy membership functions map these experiences into standardized loyalty scores; weighted convolutions aggregate data from individual visitors up to destination and regional tiers; and regression models yield tailored predictions across distinct socioeconomic profiles. Rather than treating fuzzy aggregation and regression as interchangeable, the framework uses fuzzy logic to formalize nuanced qualitative experiences and regression to model scenario-based links between visitor profiles and their calculated loyalty scores.

2.5. Research gap and questions

Three gaps motivate the study. First, mainstream destination-loyalty research concentrates on image, value, satisfaction, service quality, or place attachment, whereas the external social environment is often embedded within broader constructs rather than modelled as a separate destination-management domain. Second, studies of host-guest relations usually assess emotional solidarity or interaction quality at one analytical level; they rarely distinguish expected from experienced positive and negative encounters and then aggregate individual knowledge to destination and regional assessments. Third, segmentation studies identify heterogeneous visitor groups, but few models integrate fuzzy experiential evaluation with region-specific

prediction for an explicitly defined socioeconomic profile. These limitations are especially relevant in the Visegrad countries, where destinations operate within a shared Central European setting but differ in regional economies, tourism structures, service cultures, and visitor markets.

The study addresses these gaps through the following research questions:

RQ1: How can tourists' expected and experienced positive and negative social encounters be transformed into a normalized assessment of the external social environment's contribution to destination loyalty?

RQ2: How can destination-level assessments be aggregated into an interpretable regional loyalty indicator?

RQ3: How can socioeconomic visitor characteristics be incorporated to generate region-specific predicted loyalty levels for scenario planning?

The following sections are structured as follows. Section 3 presents the information and expert models, fuzzy formalization, aggregation procedures, and regression algorithm. Section 4 reports the application to V4 data and selected regions. Section 5 interprets the results in relation to previous studies and discusses theoretical, managerial, and methodological implications. Section 6 concludes and outlines directions for future research.

3. Materials and Methods

3.1. Material

One of the parts of the study was the approbation of an expert model for assessing the influence of the external social environment on the formation of loyalty to the destination, based on real data in the countries of the Visegrad Group (Czech Republic, Hungary, Poland, Slovakia) (Gavurova & Polishchuk, 2026). For this, a comprehensive questionnaire survey of 2,343 participants of the tourist movement was implemented in the period from March to December 2021. This survey was made possible thanks to the cooperation of several organizations. Participants of the tourist movement expressed their impressions about the visited destinations in the regions of the V4 countries for the period from 2017 to 2021. The research questionnaire contained 132 questions, which were grouped into 16 blocks. From a statistical point of view, the research questionnaire met the requirements of forming a statistical sample of data, which is confirmed by the demographic characteristics and the completeness of the elements of the researched issues.

3.2. Formal formulation of the evaluation problem

Consider some destinations $D = \{D_1; D_2; \dots; D_{R_n}\}$ in regions $R = \{R_1; R_2; \dots; R_n\}$. It is necessary to assess the influence of the external social environment on the formation of loyalty to the destination, with the aim of managing social changes, in scenario planning of tourism business and regional policy. The evaluation is based on the experience of the participants of the tourist movement $E = \{e_1; e_2; \dots; e_m\}$, who have already visited the destinations and provided feedback. Receiving feedback in this study is offered using K_{IES} – an information model for assessing the influence of the external social environment on the formation of tourists' loyalty to the destination. The collection of reviews was accompanied by taking into account the membership of the participants of the tourist movement and the social class S_{IES} . To obtain knowledge, reviews were processed by M_{IES} – an expert model for assessing the influence of the external social environment on the formation of tourists' loyalty to the destination.

Let the system-theoretical-multiple model of the problem of assessing the influence of the external social environment on the formation of loyalty to the destination is presented as follows:

$$\{D, R, E, K_{IES}, S_{IES}, M_{IES} | Y(f)\}. \quad (1)$$

As a result, the initial estimate $Y(f) = \{NE(D); GA(R); PL(S_{IES}, R)\}$, consisting of: $NE(D)$ – normalized assessment of the influence of the external social environment on the formation of tourist loyalty to the destination; $GA(R)$ – a generalized assessment of the influence of the external social environment on the formation of the loyalty of tourists in the region; $PL(S_{IES}, R)$ – is the predicted level of influence of the external social environment on the formation of loyalty to tourists in the region, relative to a certain social class. The initial assessment $Y(f)$ contains the content of the validity of proactive decision-making at the level of tourism business and regional authorities to improve the quality-of-service provision and increase the image of the location.

To solve the current problem, the following management participants are determined:

Participants of the tourist movement (experts) - respondents who have already visited destinations and provided feedback on the influence of the external social environment on the formation of loyalty to the destination.

The person making the decision (DM) is:

- a potential tourist making a reasoned choice of destinations, based on the initial level of loyalty to the destination in relation to the influence of the external social environment;
- a regional government that aims to manage social change to increase the attractiveness of the region;
- tourism business seeking to gain knowledge based on data processing in order to increase the tourist flow.

The structural diagram of the expert model for assessing the influence of the external social environment on the formation of loyalty to the destination is presented in the following form, fig. 1.

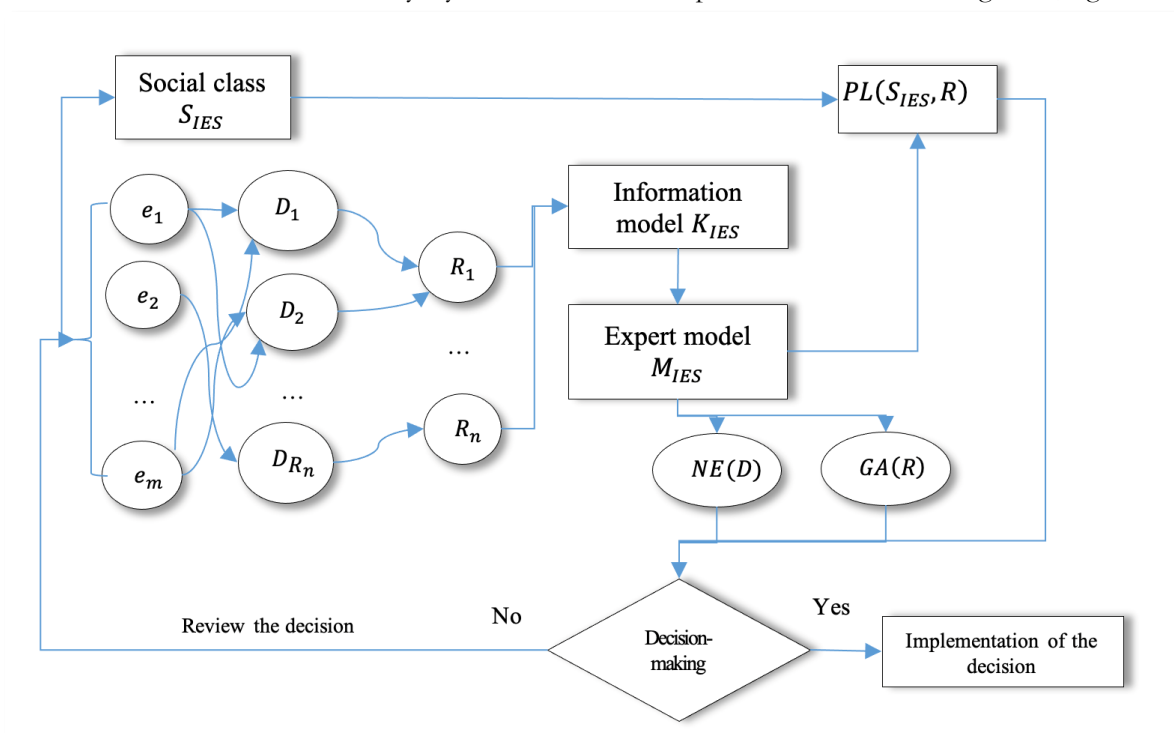


Figure 1. Structural diagram of the expert model

Figure 1 displays the structural diagram of the expert model. Here, at the entrance, we have participants of the tourist movement E , who visited some destinations D in region R . According to the participants of

the tourist movement, belonging to the social class S_{IES} is taken into account. Reviews of participants in the tourist movement are processed with the help of K_{IES} – an information model for assessing the influence of the external social environment on the formation of tourists' loyalty to the destination. After that, the assessment is carried out with the help of M_{IES} – an expert model for assessing the influence of the external social environment on the formation of tourists' loyalty to the destination. As a result, the following output estimates of $NE(D)$, $GA(R)$ and $PL(S_{IES}, R)$ are obtained. Using the initial data, the decision of the DM is made. If the obtained result satisfies the DM, then the decision is implemented, otherwise, the decision is revised.

3.3. Information model for assessing the influence of the external social environment on the formation of tourists' loyalty to the destination

Let a set of criteria be proposed, according to which reviews will be collected from the participants of the tourist movement regarding the expected and actual experience of the attitude of the external social environment at the destination. The criteria represent some questions to which the participants of the tourist movement need to provide one of the answer options. Such answer options are formalized by linguistic variables from the term set $H = \{h_1; h_2; h_3; h_4\}$ regarding the positive and negative aspects of the destination.

The following questions and their criteria are suggested for expected and actual experiences of positive aspects:

1. What POSITIVE aspects did you EXPECT/ASSUMED to experience in the area of the attitude of residents towards visitors in the destination you visited? ($h_1 = \{\text{Unexpected; Expected}\}$);
2. What POSITIVE aspects did you actually EXPERIENCE to experience in the area of the attitude of residents towards visitors in the destination you visited? ($h_2 = \{\text{Haven't experienced; Experienced}\}$).

The set of criteria is as follows:

- K_{P1} – honesty of local residents and sellers;
- K_{P2} – honesty of guides and travel agents;
- K_{P3} – warm hospitality of residents;
- K_{P4} – good social skills of the population;
- K_{P5} – good social skills of service personnel.

The following questions and their criteria are suggested for expected and actual experience of negative aspects:

3. What NEGATIVE aspects did you EXPECT to experience in the area of the attitude of residents towards visitors in the destination you visited? ($h_3 = \{\text{Unexpected; Expected}\}$);
4. What NEGATIVE aspects did you actually EXPERIENCE to experience in the area of the attitude of residents towards visitors in the destination you visited? ($h_4 = \{\text{Haven't experienced; Experienced}\}$).

The set of criteria is as follows:

- dishonesty of local residents and sellers;
- dishonesty of guides and travel agents;
- poor hospitality of residents;
- poor social skills of the local population;
- poor social skills of service personnel.

The participant in the tourist movement needs to choose the option close to the truth in terms of evaluation criteria. Of course, many questions are open. This means that the expert model will not depend on their number, and other researchers can always adjust it to their research region.

During the collection of reviews, the affiliation of the participants of the tourist movement and a certain social class S_{IES} is taken into account. That is, we have a set of values $S_{IES} = (sie_1, sie_2, \dots, sie_l)$, which represent some demographic data of the participants of the tourist movement.

Demographic data of participants in the tourist movement may include the following (Skare et al., 2023):

- sie_1 – date of birth of the tourist movement participant.
- sie_2 – primary socio-economic status. This indicator is unified and has one of the following values: Student; Employed; Unemployed; Maternity leave/guardianship; Retiree.
- sie_3 – data on marital status. The following answers are offered: Single; Married; Divorced; Widower/Widow.
- sie_4 – information about the education of the participant of the tourist movement. The following answer options are offered here: Elementary; High School; College/University.
- sie_5 – average monthly net income of a participant in the tourist movement.

3.4. Expert model for assessing the influence of the external social environment on the formation of tourists' loyalty to the destination – M_{IES}

An expert model capable of assessing the influence of the external social environment on the formation of tourists' loyalty to the destination is proposed. Uncertainty of incoming expert evaluations is revealed on the basis of fuzzy logic and intellectual analysis of data processing and knowledge acquisition. The adjustment of the model takes into account the psychological properties of the individual, regarding the expected and actual travel experience, through the prism of positive and negative aspects. The expert evaluation model consists of three stages, each of which is aimed at obtaining one of the initial evaluation values $Y(f) = \{NE(D); GA(R); PL(S_{IES}, R)\}$.

In the early stage of the analytical processing, the data obtained according to the information model is processed. Based on reviews, knowledge is obtained about the influence of the external social environment on the formation of tourist loyalty to the destination, using fuzzy logic.

Table 1 shows input expert data from some tourist participant from set E at destination D , taking into account his demographics.

Table 1

Input expert data			
	Criterion	Expected experience	Real experience
Positive aspects	K_{P1}	$(h_1)_{P1}$	$(h_2)_{P1}$
	K_{P2}	$(h_1)_{P2}$	$(h_2)_{P2}$
	...	...	...
	K_{P5}	$(h_1)_{P5}$	$(h_2)_{P5}$
Negative aspects	K_{N1}	$(h_3)_{N1}$	$(h_4)_{N1}$
	K_{N2}	$(h_3)_{N2}$	$(h_4)_{N2}$
	...	...	...
	K_{N5}	$(h_3)_{N5}$	$(h_4)_{N5}$
Demographic data			
sie_1	sie_1	...	sie_5

Where $(h_k)_{Pu}$ and $(h_k)_{Nu}$ – linguistic evaluations, sie_u – demographic data of the participant of the tourist movement, k – the answer variant of the linguistic variable, u – number of criteria/number of demographic data, $u = \overline{1,5}$; $k = \overline{1,4}$.

Thus, at the input of the model, for each expert we have a set of judgments regarding the expected and real experience of the attitude of the external social environment at the destination, taking into account its demographic data.

To obtain a normalized estimate of $NE(D)$, the logic of the psychological properties of the behavior of the participants of the tourist movement and a fuzzy logical conclusion is taken into account. As is well known, a tourist gets a good impression of a destination when the expectation matches the actual experience or the actual experience is better than the expected one. Boolean algebra is proposed to formalize feedback:

- Score for positive aspects regarding expected experience:

$$\varphi_{P1} = \begin{cases} 1, & \text{if } h_1 = \{\text{Expected}\}; \\ 0, & \text{if } h_1 = \{\text{Unexpected}\}. \end{cases} \quad (2)$$

- Score for positive aspects on real experience:

$$\varphi_{P2} = \begin{cases} 1, & \text{if } h_2 = \{\text{Experienced}\}; \\ 0, & \text{if } h_2 = \{\text{Haven't experienced}\}. \end{cases} \quad (3)$$

- Score for negative aspects relative to expected experience:

$$\varphi_{N3} = \begin{cases} 1, & \text{if } h_3 = \{\text{Expected}\}; \\ 0, & \text{if } h_3 = \{\text{Unexpected}\}. \end{cases} \quad (4)$$

- Score for negative aspects on real experience:

$$\varphi_{N4} = \begin{cases} 1, & \text{if } h_4 = \{\text{Experienced}\}; \\ 0, & \text{if } h_4 = \{\text{Haven't experienced}\}. \end{cases} \quad (5)$$

After that, the sum of the scored points is calculated according to the evaluation criteria according to the following system of convolutions:

$$\begin{cases} Z_{P1}(e_i) = \sum_{u=1}^5 (\varphi_{P1})_{Pui}, \\ Z_{P2}(e_i) = \sum_{u=1}^5 (\varphi_{P2})_{Pui}, \\ Z_{N3}(e_i) = \sum_{u=1}^5 (\varphi_{N3})_{Nui}, \\ Z_{N4}(e_i) = \sum_{u=1}^5 (\varphi_{N4})_{Nui}. \end{cases} \quad (6)$$

Where e_i – is a participant in tourist traffic, in some destination D , $i = \overline{1, m}$.

If there are large discrepancies between the expected and actual attitudes of the external social environment at the destination, then based on the psychology of individuals, we will have negative impressions of the trip. This needs to be taken into account and a distinction must be made between the expected and the experience, considering the positive and negative aspects of the trip. By conducting experiments on real evaluation data of 2,343 participants of the tourist movement in the countries of the Visegrad Group (Gavurova & Polishchuk, 2026), it was proven that differences in positive aspects will give a higher initial assessment than in negative ones. Therefore, for the formalization of this and the possibility of calculation, quantitative degrees, are introduced into consideration.

For positive aspects, the degree α_1 is determined as follows:

$$\begin{cases} \text{IF } Z_{P1}(e_i) = Z_{P2}(e_i) \text{ THEN } \alpha_1 = 1 \text{ ELSE,} \\ \text{IF } Z_{P1}(e_i) < Z_{P2}(e_i) \text{ THEN } \alpha_1 = \frac{3}{5} \text{ ELSE,} \\ \text{IF } Z_{P1}(e_i) > Z_{P2}(e_i) \text{ THEN } \alpha_1 = \frac{6}{5}. \end{cases} \quad (7)$$

For negative aspects, degree α_2 is obtained:

$$\begin{cases} \text{IF } Z_{N3}(e_i) = Z_{N4}(e_i) \text{ THEN } \alpha_2 = 1 \text{ ELSE,} \\ \text{IF } Z_{N3}(e_i) < Z_{N4}(e_i) \text{ THEN } \alpha_2 = \frac{8}{5} \text{ ELSE,} \\ \text{IF } Z_{N3}(e_i) > Z_{N4}(e_i) \text{ THEN } \alpha_2 = \frac{7}{5}. \end{cases} \quad (8)$$

The value of degrees is obtained experimentally based on real data (Gavurova & Polishchuk, 2026), and the system analyst can change them if necessary.

Because the participants of the tourist movement get more disappointment in the trip if the positive aspects of the experience do not meet their expectations. Then the function of belonging is considered, which can take into account the real experience of the participants of the tourist movement regarding the influence of the external social environment on the formation of loyalty to the destination:

$$\mu(e_i) = \frac{1}{2} * (f_P(e_i) + (1 - f_N(e_i))), \quad (9)$$

$$\text{Where } f_P(e_i) = \begin{cases} 0, & Z_{P2}(e_i) < 0; \\ \left(\frac{Z_{P2}(e_i)}{5}\right)^{\alpha_1}, & 0 \leq Z_{P2}(e_i) < 5; \\ 1, & Z_{P2}(e_i) \geq 5. \end{cases} \quad f_N(e_i) = \begin{cases} 0, & Z_{N4}(e_i) < 0; \\ \left(\frac{Z_{N4}(e_i)}{g_h}\right)^{\alpha_2}, & 0 \leq Z_{N4}(e_i) < 5; \\ 1, & Z_{N4}(e_i) \geq 5. \end{cases}$$

The value $\mu(e_i)$ is called the level of influence of the external social environment on the formation of loyalty to the destination for the participant of the tourist movement e_i . The level of $\mu(e_i)$ approaches 1 when the maximum satisfaction and positive experience of the tourist e_i regarding the attitude of the external social environment in destination D occurs.

In the next step, a weighted average convolution is used to obtain $NE(D)$ – a normalized assessment of the influence of the external social environment on the formation of tourists' loyalty to the destination:

$$NE(D) = \frac{1}{nd} \sum_{i=1}^{nd} \mu(e_i). \quad (10)$$

Where nd is the number of tourist movement participants in the destination D .

Successively, the following stage of the analytical processing involves a generalized assessment of the influence of the external social environment on the formation of tourist loyalty in the region. Similarly, a weighted average convolution over the entire region R is used:

$$GA(R_j) = \frac{1}{n(R_j)} \sum_{i=1}^{n(R_j)} \mu(e_i). \quad (11)$$

Where $n(R_j)$ is the number of participants in the tourist movement in the region R_j . The generalized assessment $GA(R_j) \in [0.5; 1]$, characterizes the level of formation of loyalty of the region to tourists, relative to the external social environment.

Using the generalized $GA(R_j)$ estimates, it is possible to deduce the linguistic level of the influence of the external social environment on the formation of the region's loyalty to tourists. For this, the obtained value of $GA(R_j)$ in the region R_j is mapped to one of the variable term sets $T_{IES} = \{ies_1, ies_2, \dots, ies_5\}$, putting the following content:

$GA(R_j) \in (0.9; 1] - ies_1$ = “high level of loyalty of the region in relation to the influence of the external social environment”;

- $GA(R_j) \in (0.8; 0.9] - ies_2$ = “the level of loyalty of the region in relation to the influence of the external social environment is above average”;
- $GA(R_j) \in (0.7; 0.8] - ies_3$ = “average level of loyalty of the region in relation to the influence of the external social environment”;
- $GA(R_j) \in (0.6; 0.7] - ies_4$ = “low level of loyalty of the region in relation to the influence of the external social environment”;

- $GA(R_j) \in [0; 0.6] - ies_5 =$ “very low level of loyalty of the region in relation to the influence of the external social environment”.

Setting the quantitative levels was carried out experimentally, using real feedback data from 2343 participants of the tourist movement and their impressions of the external social environment (Gavurova & Polishchuk, 2026). It is noted that such a setting can be changed by a system analyst, for example by applying machine learning and artificial intelligence methods.

In the final stage of the analytical processing, the predicted level of influence of the external social environment on the formation of the region's loyalty to tourists of a certain social class will be derived – $PL(S_{IES}, R)$.

For this purpose, it is proposed to build multiple regression equations separately for the studied regions $R = \{R_1; R_2; \dots; R_n\}$. The multiple regression parameters are a set of demographic data values of the participants of the tourist movement $S_{IES} = (sie_1, sie_2, \dots, sie_l)$. The resulting indicators are $\mu(e_i)$ – the level of influence of the external social environment on the formation of loyalty to the destination. After deriving the regression equation for some region R_j , it will be possible to derive the predicted level of influence of the external social environment on the formation of loyalty of the region to tourists of a certain social class.

Derivation of the predicted level is offered on the basis of a step-by-step algorithm.

1st step. Formalization of demographic data of participants in the tourist movement

For this, intellectual analysis of knowledge using the theory of fuzzy sets is used. According to the given demographic data, we have:

- sie_1 – date of birth of the tourist movement participant. During data formalization, the age of the tourist movement participant is obtained in years: $x_1 = 2023 - sie_1$; $x_1 \in [18; 100]$.
- sie_2 – primary socio-economic status. Quantification is obtained using the following characteristic function:

$$x_2 = \begin{cases} 0,2 & \text{if } sie_2 = "Unemployed"; \\ 0,4 & \text{if } sie_2 = "Maternity leave / guardianship"; \\ 0,6 & \text{if } sie_2 = "Student"; \\ 0,8 & \text{if } sie_2 = "Retiree"; \\ 1 & \text{if } sie_2 = "Employed". \end{cases} \quad (12)$$

- sie_3 – data on marital status. The following answers are offered: Single; Married; Divorced; Widower/Widow. The transition from linguistic to quantitative evaluations is offered with the help of the function:

$$x_3 = \begin{cases} 0,6 & \text{if } sie_3 = "Widower/Widow"; \\ 0,7 & \text{if } sie_3 = "Divorced"; \\ 0,8 & \text{if } sie_3 = "Single"; \\ 0,9 & \text{if } sie_3 = "Married". \end{cases} \quad (13)$$

- sie_4 – information about the education of the participant in the tourist movement. The following answer options are offered here: Elementary; High School; College/University. Quantification is assigned using the following characteristic function:

$$x_4 = \begin{cases} 0,4 & \text{if } sie_4 = "Elementary"; \\ 0,6 & \text{if } sie_4 = "High School"; \\ 1 & \text{if } sie_4 = "College/University". \end{cases} \quad (14)$$

- sie_5 – average monthly net income of a participant in the tourist movement. Gradation of net income is proposed using the following characteristic function:

$$- x_5 = \begin{cases} 0,2 & \text{if } sie_5 = "< 221 \text{ EUR}"; \\ 0,3 & \text{if } sie_5 = "221 - 330 \text{ EUR}"; \\ 0,4 & \text{if } sie_5 = "331 - 430 \text{ EUR}"; \\ 0,5 & \text{if } sie_5 = "431 - 540 \text{ EUR}"; \\ 0,6 & \text{if } sie_5 = "541 - 720 \text{ EUR}"; \\ 0,7 & \text{if } sie_5 = "721 - 1090 \text{ EUR}"; \\ 0,8 & \text{if } sie_5 = "1091 - 1810 \text{ EUR}"; \\ 0,9 & \text{if } sie_5 = "1811 - 2540 \text{ EUR}"; \\ 1 & \text{if } sie_5 = "> 2540 \text{ EUR}"; \end{cases} \quad (15)$$

The obtained number of parameters $X = \{x_1, x_2, \dots, x_5\}$ as well as $n(R_j)$ is the number of participants in the tourist movement in the region R_j .

2nd step. Entering input data

The input data for the region R_j is presented in the form of Table 2.

Table 2

Input data for deriving the regression equation

	sie_1	sie_2	...	sie_5	PL
1	x_{11}	x_{12}	...	x_{15}	$\mu(e_1)$
2	x_{21}	x_{22}	...	x_{25}	$\mu(e_2)$
...	...	...	...	...	...
$n(R_j)$	$x_{n(R_j)1}$	$x_{n(R_j)2}$	...	$x_{n(R_j)5}$	$\mu(e_{n(R_j)})$

Where x_{il} is the multiple regression parameter for the i -th participant of the tourist movement, the l -th value of demographic data, $\mu(e_l)$ is the level of influence of the external social environment on the formation of loyalty to the destination for the participant of the tourist movement e_l .

3rd step. Finding elements of matrix A_1

By multiplying the matrix X by X^T the matrix A_1 is obtained:

$$A_1 = X \cdot X^T. \quad (16)$$

$$\text{Where is the matrix } X = \begin{pmatrix} x_{11} & x_{21} & \dots & x_{n(R_j)1} \\ x_{12} & x_{22} & \dots & x_{n(R_j)2} \\ \dots & \dots & \dots & \dots \\ x_{15} & x_{25} & \dots & x_{n(R_j)5} \end{pmatrix},$$

$$\text{Then } X^T = \begin{pmatrix} x_{11} & x_{12} & \dots & x_{15} \\ x_{21} & x_{22} & \dots & x_{25} \\ \dots & \dots & \dots & \dots \\ x_{n(R_j)1} & x_{n(R_j)2} & \dots & x_{n(R_j)5} \end{pmatrix}.$$

The matrix A_1 will be 5×5 in size and will characterize the parameters relative to the observations. The matrix A_1 is symmetric, and its elements are denoted by $a_{kr}, k = \overline{1,5}, r = \overline{1,5}$.

4th step. The inverse matrix to the matrix A_1 is found

The inverse matrix can be found using the Gauss-Jordan method, or using the matrix of algebraic additions:

$$A_2 = (X \cdot X^T)^{-1}. \quad (17)$$

5th step. The inverse matrix is multiplied by the input matrix

Now the obtained inverse matrix (17) must be multiplied by the matrix of input data X :

$$A_3 = A_2 \cdot X = (X \cdot X^T)^{-1} \cdot X. \quad (18)$$

The resulting matrix will have dimensions of $5 \times n(R_j)$ and will display the number of observations relative to the number of parameters.

6th step. Determination of the coefficients of the multiple linear regression equation

At this step, to determine the coefficients of the multiple linear regression equation, the matrix A_4 , is formed by multiplying the matrix A_3 by the transposed resulting PL indicator:

$$A_4 = A_3 \cdot PL^T = (X \cdot X^T)^{-1} \cdot X \cdot PL^T. \quad (19)$$

$$\text{Is obtained } A_4 = \begin{pmatrix} \omega_1 \\ \omega_2 \\ \vdots \\ \omega_5 \end{pmatrix}.$$

Matrix A_4 will be 5×1 in size and will contain the coefficients of the multiple linear regression equation.

7th step. Derivation of the multiple linear regression equation

Using the elements of matrix A_4 , a multiple linear regression equation is prescribed:

$$PL(S_{IES}, R) = \omega_1 x_1 + \omega_2 x_2 + \dots + \omega_5 x_5. \quad (20)$$

8th step. Derivation of the predicted level of influence of the external social environment for tourists of a certain social class

In the last step, the parameters of the social class of a potential tourist $X = \{x_1^*, x_2^*, \dots, x_5^*\}$, are substituted to predict the impact of the external social environment $PL(S_{IES}, R)$ on him in the region R .

Thus, an algorithm is provided that allows you to obtain the predicted indicators of $PL(S_{IES}, R)$ based on multiple linear regression and given dependencies of S_{IES} in the region R .

4. RESULTS

To illustrate the developed expert model for assessing the influence of the external social environment on the formation of loyalty to the destination, an example based on a set of real data is given.

The evaluation example is illustrated on three regions in the V4 countries: $R = \{R_1 - \text{Nitra region (SK)}; R_2 - \text{Moravian-Silesian Region (CZ)}; R_3 - \text{Podkarpackie voivodeship (PL)}\}$. Based on the given set of regions and destinations, the derivation of the initial estimate $Y(f) = \{NE(D); GA(R); PL(S_{IES}, R)\}$.

According to the information model for assessing the influence of the external social environment on the formation of loyalty to the destination, input data is collected from participants in the tourist movement. The entire set of input data is illustrated in the database (Gavurova & Polishchuk, 2026). Table 3 shows data from a tourist movement participant (), for example, for region – Moravian-Silesian Region (CZ).

Table 3

Input data e_6 of a tourist movement participant

	Criterion	Expected experience	Real experience
Positive aspects	K_{P1}	Expected	Experienced
	K_{P2}	Unexpected	Haven't experienced
	K_{P3}	Expected	Experienced
	K_{P4}	Unexpected	Experienced
	K_{P5}	Expected	Experienced
Negative aspects	K_{N1}	Unexpected	Haven't experienced
	K_{N2}	Unexpected	Haven't experienced
	K_{N3}	Unexpected	Haven't experienced
	K_{N4}	Expected	Haven't experienced

	K_{N5}	Unexpected	Haven't experienced	
Demographic data				
1997	Student	Single	College/University	331 – 430 EUR

Next, a three-stage calculation using an expert model is considered, each of which is aimed at obtaining one of the values of the initial assessment $Y(f) = \{NE(D); GA(R); PL(S_{IES}, R)\}$.

In the early stage, input data is processed to obtain $NE(D)$ a normalized assessment of the influence of the external social environment on the formation of tourist loyalty to the destination. Boolean algebra is used to formalize feedback, formulas (2)–(5). After that, the sum of scored points is calculated by convolution (6). Next, the real experience of the participants of the tourist movement regarding the influence of the external social environment on the formation of loyalty to the destination is taken into account according to formula (9), and the quantitative degrees α_1, α_2 are determined according to (7)–(8).

The results of the calculation fragments for the regions $R_1 - R_3$ and their destinations D are given in Table 4. Without reducing the generality, we will not provide the real data of the destinations, but only their conventional designations.

Table 4

Fragments of calculation for deriving estimates $NE(D)$

Region	Participant of the tourist movement	Destination	ZP_1	ZP_2	ZN_3	ZN_4	$f_P(e)$	$f_N(e)$	$\mu(e)$
R_1	e_1	D_1	5	5	0	0	1	0	1
	e_2	D_2	5	4	0	0	0.765	0	0.883
	...	...	...	...	...	...	...	...	...
	e_{53}	D_4	5	0	0	0	0	0	0.5
R_2	e_1	D_1	5	5	5	5	1	1	0.5
	e_2	D_2	1	4	2	1	0.875	0.105	0.885
	...	...	...	...	...	...	...	...	...
	e_6	D_4	3	4	1	1	0.875	0	0.937
	...	...	...	...	...	...	...	...	...
	e_{46}	D_1	0	0	0	0	0	0	0.5
R_3	e_1	D_1	5	5	0	0	1	0	1
	e_2	D_2	0	5	0	5	1	1	0.5
	...	...	...	...	...	...	...	...	...
	e_{43}	D_3	5	5	1	1	1	0	1

Next, to obtain $NE(D)$ – a normalized assessment of the influence of the external social environment on the formation of tourists' loyalty to the destination, a weighted average convolution according to formula (10) is used. The calculation results are given in Table 5.

Table 5

Calculation of normalized estimates of $NE(D)$

Region	Destination	D_1	D_2	D_3	D_4	D_5	D_6	D_7
R_1	Sum $\mu(e)$	7.5	8.57	8.146	6.452	4.367	4.844	5.944
	Number nd	8	10	9	8	5	6	7
	$NE(D)$	0.938	0.857	0.905	0.807	0.873	0.807	0.849
R_2	Sum $\mu(e)$	12.487	7.29	2.7	4.937	6.6	3	-
	Number nd	17	10	3	5	8	3	-
	$NE(D)$	0.735	0.729	0.9	0.987	0.825	1	-
R_3	Sum $\mu(e)$	7.237	6.991	5.994	4.98	3.483	4	3.263
	Number nd	8	8	7	6	5	4	5
	$NE(D)$	0.905	0.874	0.856	0.83	0.697	1	0.6532

At the successive stage of the analytical processing, a generalised assessment of the influence of the external social environment on the formation of tourist loyalty in the region is derived, based on the weighted average convolution (11) within regions $R_1 - R_3$: $GA(R_1) = 0.865$; $GA(R_2) = 0.805$; $GA(R_3) = 0.836$.

Using the generalized estimates $GA(R_1) - GA(R_3)$ the linguistic level of the influence of the external social environment on the formation of loyalty in the region is derived, using the value of the term set T_{IES} . It turns out that the estimates of the considered regions fall into the same intervals, then: $GA(R) \in (0.8; 0.9] - ies_2 =$ “the level of loyalty of the region in relation to the influence of the external social environment is above average”.

At the final stage of the analytical processing, the predicted level of influence of the external social environment on the formation of the region's loyalty to tourists of a certain social class will be derived – $PL(S_{IES}, R)$. For this, regression equations are built for the studied regions, based on a step-by-step algorithm.

1st step. Formalization of demographic data of participants in the tourist movement

Formulas (12)-(15) are used for this purpose. The results of the calculation fragments are given in Table 6.

Table 6

Fragments of the formalization of demographic data

Region	Participant of the tourist movement	sie_1	sie_2	sie_3	sie_4	sie_5	x_1	x_2	x_3	x_4	x_5
R_1	e_1	2001	Student	Single	High School	221 – 330 EUR	22	0.6	0.8	0,6	0.3
	e_2	1975	Retiree	Single	College/University	221 – 330 EUR	48	0.8	0.8	1	0.3
	...	...	...	...	...	...	...	...	...	...	...
	e_{53}	1992	Employed	Single	College/University	More than 2540 EUR	21	1	0.8	1	1
R_2	e_1	1995	Student	Single	High School	431 – 540 EUR	28	0.6	0.8	0.6	0.5
	e_2	1997	Student	Single	High School	Less than 221 EUR	26	0.6	0.8	0.6	0.2
	...	...	...	...	...	...	...	...	...	...	...
	e_6	1997	Student	Single	College/University	331 – 430 EUR	26	0.6	0.8	1	0.4
	...	...	...	...	...	...	...	...	...	...	...
	e_{46}	1997	Student	Single	College/University	721 – 1090 EUR	26	0.6	0.8	1	0.7
R_3	e_1	2001	Student	Single	High School	Less than 221 EUR	22	0.6	0.8	0.6	0.2
	e_2	1997	Student	Single	College/University	331 – 430 EUR	26	0.6	0.8	1	0.4
	...	...	...	...	...	...	...	...	...	...	...
	e_{43}	1978	Employed	Married	College/University	1811 – 2540 EUR	45	1	0.9	1	0.9

2nd step. Entering input data

Thus, the input data for the studied regions $R_1 - R_3$ are obtained. For example, a fragment of data for region R_1 is presented in the form of Table 7.

Table 7

Fragment of input data for the region R_1

	x_1	x_2	x_3	x_4	x_5	PL
1	22	0.6	0.8	0.6	0.3	1
2	48	0.8	0.8	1	0.3	0.883
...	...	...	...	...	...	...
27	44	1	0.7	0.6	0.7	1
...	...	...	...	...	...	...
53	31	1	0.8	1	1	0.5

Next, a step-by-step calculation (steps 3-7) takes place to derive multiple linear regression equations separately for regions $R_1 - R_3$.

The technical calculation was implemented in the authors' software. The workflow follows the published algorithm: (i) formalization of age, employment status, marital status, education, and income as

x_1 – x_5 ; (ii) construction of the cross-product matrix; (iii) inversion of the resulting 5×5 matrix; (iv) calculation of the coefficient vector; (v) formulation of the no-intercept regression equation; and (vi) substitution of a prospective tourist's profile to obtain a scenario-specific prediction. The re-estimated equations and their statistical validation are reported in Section 4.1.

The following no-intercept multiple linear regression equations were re-estimated from the complete respondent-level records in the supplied regional sheets:

$$P_{LSIES,R1} = -0.0007 \cdot x_1 - 0.0324 \cdot x_2 + 1.0423 \cdot x_3 + 0.1279 \cdot x_4 - 0.0779 \cdot x_5$$

$$P_{LSIES,R2} = 0.0057 \cdot x_1 + 0.0082 \cdot x_2 + 0.9555 \cdot x_3 - 0.1247 \cdot x_4 - 0.1508 \cdot x_5$$

$$P_{LSIES,R3} = -0.0097 \cdot x_1 + 0.4333 \cdot x_2 + 1.0963 \cdot x_3 - 0.0484 \cdot x_4 - 0.0918 \cdot x_5$$

8th step. Derivation of the predicted level of influence of the external social environment for tourists of a certain social class

In the last step, the social class parameters of the potential tourist are substituted, for example, $S_{IES} = (1975; Retiree; Single; College/University; 1091 - 1810 \text{ EUR})$, or formalized data $X = \{48; 0.8; 0.8; 1; 0.8\}$, then: $P_{LSIES,R1} = 0.8383$; $P_{LSIES,R2} = 0.7970$; $P_{LSIES,R3} = 0.6345$.

For the illustrative profile, the recalculated predictions are 0.8383 for Nitra (above-average category), 0.7970 for the Moravian-Silesian region (average category), and 0.6345 for Podkarpackie (average category). These values are scenario-specific fitted outputs and should not be interpreted as causal effects or as statistically significant regional differences.

4.1. Statistical validation of the regression component

To address the statistical-validation concern, the regression component was re-estimated from the supplied Excel database using the individual-level records in sheets R1–R3. The dependent variable was the respondent-level fuzzy loyalty score $m(e)$, denoted P_{LSIES} in the manuscript, and the predictors were x_1 (age), x_2 (employment status), x_3 (marital status), x_4 (education), and x_5 (monthly income). The published algorithm specifies a regression through the origin; the validation therefore preserves this specification. Because the model has no intercept, R^2 and adjusted R^2 are reported in their uncentred form, and the overall F-test tests the joint null hypothesis that all five slope coefficients equal zero.

$$P_{LSIES,R} = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5$$

The two non-observation rows at the bottom of each regional sheet, which contain summary formulas, were excluded before estimation. The resulting regional sample sizes were 53 for Nitra, 46 for Moravian-Silesian, and 43 for Podkarpackie. All five predictors and $m(e)$ were available for every retained record, so the number of complete cases equals n in each region and no respondent record was excluded because of missing data. Respondent identifiers were unique within each regional sheet. Because each retained row represents a distinct respondent, respondent-level independence was assumed; however, repeated destination labels mean that within-destination dependence cannot be ruled out and is acknowledged as a limitation. OLS estimates were supplemented with HC3 heteroskedasticity-consistent standard errors. Model stability was assessed by leave-one-out cross-validation and by 10,000 within-region bootstrap resamples (seed = 20260827).

Table 8

Regional regression fit and sample accounting

Region	n	Complete	Excluded	R ²	Adj. R ²	F (df)	p	SER	LOOCV RMSE	LOOCV MAE
Nitra	53	53	0	0.9446	0.9388	163.72 (48)	<0.001	0.2195	0.2326	0.1999
Moravian-Silesian	46	46	0	0.9328	0.9246	113.80 (41)	<0.001	0.2286	0.2418	0.2202
Podkarpackie	43	43	0	0.9350	0.9264	109.24 (38)	<0.001	0.2347	0.2717	0.2134

Note: SER = square root of the residual mean square; LOOCV = leave-one-out cross-validation. The F statistic uses 5 and n–5 degrees of freedom. R² is uncentred because the published model has no intercept.

Table 9 gives the coefficient-level results. The marital-status score x_3 is positively associated with the fitted fuzzy loyalty score in all three regional models, while the remaining individual coefficients are estimated imprecisely. The robust inference is used because the residual checks do not justify relying only on homoskedastic normal-error assumptions.

Table 9

Coefficients and HC3-robust inference for the no-intercept regional models

Region	Predictor	β	HC3 SE	t	p	95% CI
Nitra	Age (years)	-0.0007	0.0040	-0.18	0.855	[-0.009, 0.007]
Nitra	Employment status	-0.0324	0.1523	-0.21	0.833	[-0.339, 0.274]
Nitra	Marital status	1.0423	0.2121	4.91	<0.001	[0.616, 1.469]
Nitra	Education	0.1279	0.1624	0.79	0.435	[-0.199, 0.455]
Nitra	Monthly income	-0.0779	0.1614	-0.48	0.632	[-0.402, 0.247]
Moravian-Silesian	Age (years)	0.0057	0.0033	1.74	0.089	[-0.001, 0.012]
Moravian-Silesian	Employment status	0.0082	0.1669	0.05	0.961	[-0.329, 0.345]
Moravian-Silesian	Marital status	0.9555	0.1642	5.82	<0.001	[0.624, 1.287]
Moravian-Silesian	Education	-0.1247	0.2246	-0.56	0.582	[-0.578, 0.329]
Moravian-Silesian	Monthly income	-0.1508	0.2422	-0.62	0.537	[-0.640, 0.338]
Podkarpackie	Age (years)	-0.0097	0.0083	-1.17	0.249	[-0.027, 0.007]
Podkarpackie	Employment status	0.4333	0.4081	1.06	0.295	[-0.393, 1.259]
Podkarpackie	Marital status	1.0963	0.2125	5.16	<0.001	[0.666, 1.527]
Podkarpackie	Education	-0.0484	0.3107	-0.16	0.877	[-0.677, 0.581]
Podkarpackie	Monthly income	-0.0918	0.4403	-0.21	0.836	[-0.983, 0.800]

Note: β = estimated coefficient; HC3 SE = heteroskedasticity-consistent standard error; t and p are based on HC3 SE; 95% CIs use the t distribution with n–5 residual degrees of freedom.

The residual diagnostics are presented in Tables 10–11 and Fig. 2. Breusch–Pagan tests did not detect heteroskedasticity at the 5% level in any region. The White test was also non-significant for Nitra and Moravian-Silesian, but it was significant for Podkarpackie ($p = .002$). Shapiro–Wilk tests rejected exact normality in all three regions, which is consistent with the discrete, bounded construction of $m(e)$ and the visible departures from the reference line in the Q–Q plots. Therefore, normality is not claimed as an exact

property of the residuals. The residual-versus-fitted plots were inspected for systematic curvature and non-constant spread; their discrete bands reflect the fuzzy scoring scale, while the Podkarpackie model shows the greatest sensitivity to individual observations. No observations were deleted on the basis of these diagnostics.

Table 10

Residual-distribution and variance diagnostics

Region	BP LM (p)	White LM (p)	Shapiro–Wilk (p)	DW*
Nitra	6.59 (0.253)	19.94 (0.461)	0.866 (<0.001)	1.852
Moravian-Silesian	5.28 (0.382)	15.43 (0.751)	0.915 (0.003)	2.145
Podkarpackie	7.59 (0.181)	38.29 (0.002)	0.844 (<0.001)	2.289

Note: BP = Breusch–Pagan; White degrees of freedom are based on the rank of the auxiliary design (20 for Nitra and Moravian-Silesian; 17 for Podkarpackie because of linear dependencies among sparse interaction terms). DW* is reported in the database row order; because the rows have no natural time or spatial ordering, it is descriptive rather than a formal independence test.

Table 11

Collinearity, leverage, and influence diagnostics

Region	Max VIF	Min tolerance	Max leverage (n)	Max Cook's D (n)	Max studentized (n > 3)
Nitra	1.55	0.643	0.218 (3)	0.112 (3)	2.32 (0)
Moravian-Silesian	2.38	0.420	0.282 (3)	0.120 (2)	1.99 (0)
Podkarpackie	5.40	0.185	0.390 (5)	1.021 (7)	3.50 (1)

Note: leverage flags use $h_i > 2k/n$; Cook's-distance flags use $D_i > 4/n$; studentized-residual flags use $|r_i| > 3$. The Podkarpackie model has one studentized-residual flag, five high-leverage observations, and seven Cook's-distance flags; this is treated as evidence of reduced stability, not as a reason to remove observations.

$$X^* = (48, 0.8, 0.8, 1.0, 0.8)$$

For the illustrative socioeconomic profile, the fitted predictions were 0.8383 for Nitra, 0.7970 for Moravian-Silesian, and 0.6345 for Podkarpackie. The 10,000-resample within-region bootstrap 95% intervals for these fitted scenario predictions were [0.7053, 0.9780], [0.6327, 0.9523], and [0.4211, 0.8765], respectively. These intervals show that the point predictions should not be read as precise ranks. The recalculated regional aggregate scores were also compared using the Kruskal–Wallis test: $H(2) = 3.113$, $p = .211$. The 95% bootstrap intervals for the regional means were [0.8079, 0.9174] for Nitra, [0.7419, 0.8647] for Moravian-Silesian, and [0.7664, 0.8993] for Podkarpackie. Pairwise bootstrap intervals for mean differences all included zero: Nitra–Moravian-Silesian = 0.0597 [−0.0202, 0.1418], Nitra–Podkarpackie = 0.0286 [−0.0557, 0.1149], and Moravian-Silesian–Podkarpackie = −0.0312 [−0.1210, 0.0610]. Thus, the regional values are retained as descriptive/model-based indicators, and no statistically significant regional heterogeneity is claimed.

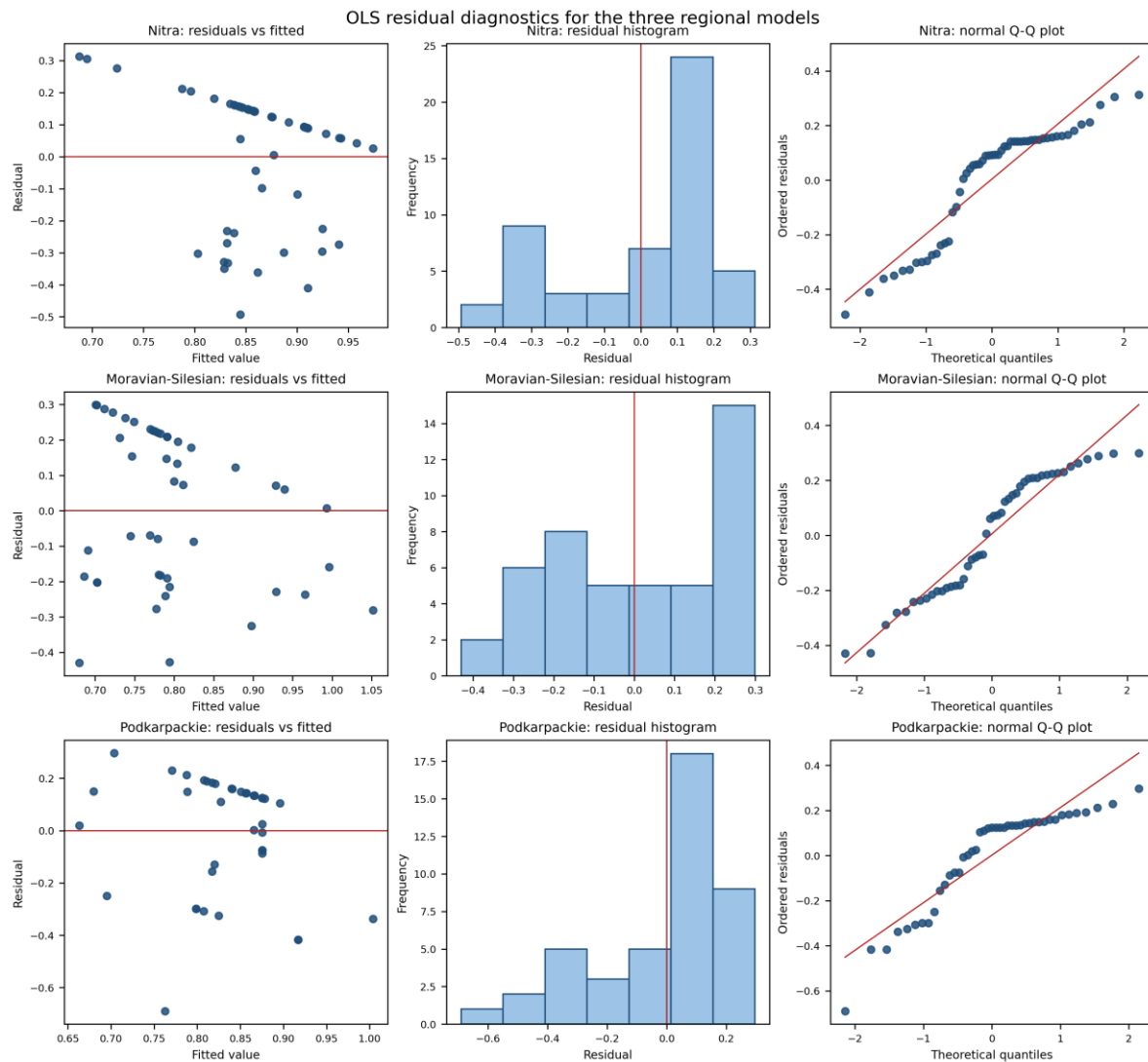


Figure 2. OLS residual diagnostics for the three regional models

5. DISCUSSION

5.1. Interpretation and comparison

The study demonstrates that the perceived external social environment can be transformed from individual reports into destination-, regional-, and segment-specific loyalty assessments. At the regional level, the generalised scores were 0.865 for the Nitra region, 0.805 for the Moravian-Silesian region, and 0.836 for the Podkarpackie voivodeship. All three values fall within the above-average linguistic category, but the destination-level results displayed considerably greater dispersion. This pattern is important because a favourable regional mean does not imply that all constituent destinations provide equally welcoming, honest, or socially competent encounters. The three regional scores are descriptive/model-based summaries; the inferential comparison reported below does not support treating their small differences as statistically significant regional effects.

The generally positive regional evaluations are consistent with the broader destination-loyalty literature, which shows that favourable destination evaluations and satisfaction support revisit and recommendation

intentions (Yoon & Uysal, 2005; Chi & Qu, 2008; Zhang et al., 2014). The present findings extend that evidence by isolating the social environment rather than treating it as an implicit part of image or service quality. The result is also compatible with research showing that service fairness and trust influence satisfaction and loyalty (Su et al., 2017) and that positive emotional experiences generated in community settings strengthen destination loyalty (Li et al., 2024).

The role assigned to honesty, hospitality, and social competence closely corresponds to emotional-solidarity research. Feeling welcomed and sympathetic understanding have been identified as direct or satisfaction-mediated antecedents of loyalty (Ribeiro et al., 2018), and emotional solidarity has remained a meaningful predictor even under pandemic conditions (Woosnam et al., 2021). The destination-level heterogeneity observed in this study also parallels the segmentation results of Styliadis et al. (2020), who identified tourist groups with different emotional bonds, images, and loyalty levels. Similarly, Styliadis et al. (2022) showed that resident-tourist interaction quality shapes image, satisfaction, and loyalty. Taken together, these comparisons support the study's premise that the social behaviour encountered at a destination is not a peripheral attribute but a substantive component of destination competitiveness.

The explicit comparison of expected and experienced positive and negative aspects provides a further contribution. The modelling logic is consistent with expectation-disconfirmation theory, according to which experienced performance is evaluated relative to a prior standard (Oliver, 1980). Pizam and Milman (1993) demonstrated the usefulness of this mechanism in destination satisfaction and showed that predictive performance improves when tourist segments are considered. In the present model, disappointment arising from an expected positive social attribute that is not experienced is distinguished from the absence of an expected negative attribute. This prevents substantively different experience patterns from receiving the same score.

The segment-specific application reveals why regional aggregates should not be used as universal predictions. For the illustrative profile of a retired, single, university-educated visitor with a monthly income of EUR 1,091–1,810, the re-estimated fitted scores were 0.8383 for Nitra, 0.7970 for the Moravian-Silesian region, and 0.6345 for Podkarpackie. The profile-specific ranking therefore follows the order Nitra, Moravian-Silesian, and Podkarpackie, but the bootstrap intervals reported in the validation analysis are wide. The implication is not that demographic variables deterministically create loyalty, but that they can support scenario-specific interpretation when uncertainty and diagnostic limitations are made explicit.

5.2. Theoretical implications

This research advances destination-loyalty literature by framing the external social environment as a meso-level bridge that links micro-level interpersonal interactions to macro-level destination and regional performance. It enriches traditional image–satisfaction–loyalty frameworks by demonstrating how individual encounters with residents and service staff can be aggregated into a comprehensive destination knowledge base. Furthermore, it bridges emotional-solidarity research with expectation-disconfirmation theory, illustrating that interpersonal warmth and perceived hospitality are judged not merely in isolation, but against the visitor's initial expectations.

From a methodological standpoint, the framework expands beyond earlier applications that restricted fuzzy logic to guest classification or used fuzzy-set Qualitative Comparative Analysis (fsQCA) solely to uncover alternative loyalty configurations. While Lau et al. (2015) highlighted the practical utility of pairing fuzzy logic with expert insight to evaluate hotel guest loyalty, and Wu (2016) integrated fuzzy logic with structural modelling to assess global destination loyalty, this study introduces a sequential, multi-tiered architecture. It seamlessly progresses from the fuzzy formalisation of social encounters to regional aggregation, culminating in regression-based forecasts for specific socioeconomic profiles. This design

aligns with the broader adoption of fuzzy approaches to model asymmetric and complex dynamics in tourism (Geremew et al., 2024), while preserving a transparent, step-by-step decision framework.

5.3. Practical implications

For destination management organisations, such a model serves as a diagnostic tool to pinpoint whether loyalty deficits stem from interactions with local residents, commercial vendors, tour guides, or frontline service personnel. It is vital to assess destination-level evaluations prior to regional aggregation, as high regional averages can easily mask underperforming destinations within the territory. Potential management interventions include establishing professional codes of conduct for vendors and guides, delivering hospitality and intercultural communication training, implementing visitor-assistance systems, establishing clear complaint channels, and launching community campaigns to foster local destination stewardship. Digital channels can support such measures: in a comparative study of 147 hotels in eight EU countries, mobile-friendly interfaces and real-time availability were identified as critical drivers of guest adoption and satisfaction (Vovk et al., 2025).

Additionally, the socioeconomic prediction phase enables the creation of tailored value propositions. A destination might exhibit high overall appeal yet prove less effective for a specific target segment, as different visitor groups bring distinct expectations and interpret social interactions differently. Developing segment-specific scenarios allows destination managers to refine marketing communications, service delivery, target-market focus, and resource distribution. Finally, the framework offers high adaptability for international benchmarking, as its core logical structure can be maintained while recalibrating evaluation criteria, fuzzy membership thresholds, and regression parameters to suit distinct national or regional environments.

5.4. Limitations and future research

Several limitations require cautious interpretation. The survey was conducted in 2021 and respondents evaluated trips undertaken between 2017 and 2021. Recall effects and the exceptional social conditions of the COVID-19 period may therefore have influenced both expectations and reported experiences. Followingly, the model uses selected indicators of honesty, hospitality, and social skills; it does not capture all dimensions of the social environment, such as discrimination, crowding, intercultural distance, perceived safety, language barriers, or online interaction with residents and providers.

The term 'social class' is represented by age, employment status, marital status, education, and income. These variables form a practical socioeconomic profile but do not exhaust the sociological meaning of class, which may also involve occupation, wealth, cultural capital, and household structure. The membership thresholds and quantitative degrees were calibrated on the available V4 data and should be externally validated before application elsewhere. In response to the statistical-validation concern, the three regional regression equations were re-estimated from the respondent-level records, with 53, 46, and 43 complete cases for Nitra, Moravian-Silesian, and Podkarpackie, respectively, and no excluded complete-case observations. The revised analysis reports coefficient estimates, HC3 robust standard errors, confidence intervals, goodness-of-fit measures, VIF/tolerance, Breusch–Pagan and White tests, residual plots, Shapiro–Wilk tests, leverage, Cook's distance, studentized residuals, and leave-one-out prediction errors. Residual normality was not fully supported, and the Podkarpackie model additionally showed a significant White test, higher collinearity, and influential observations. These findings are reported transparently rather than concealed; accordingly, the predictions are retained as scenario-specific model outputs, not causal estimates or universal regional rankings. Out-of-sample validation remains limited because the available regional samples are small and drawn from one survey wave.

Future research should use repeated or longitudinal data, compare first-time and repeat visitors, and test measurement invariance across countries and languages. The model should be validated against behavioural outcomes such as actual revisit, recommendation, complaint behaviour, and expenditure. Additional work could compare the current fuzzy-regression architecture with multilevel modelling, machine learning, and alternative fuzzy membership functions. Dynamic recalibration would also allow destination managers to update predictions as new feedback is received, while sensitivity analysis could determine how strongly regional rankings depend on thresholds, weights, and the composition of visitor segments.

6. CONCLUSIONS

The primary objective of this research was to develop an expert model to evaluate how the external social environment influences the formation of destination loyalty, using the Visegrad Group countries as a empirical case study. The study yields several key scientific contributions. It introduces a novel information model designed to evaluate the impact of the social environment on visitor loyalty by assessing five specific criteria that capture tourists' anticipated and actual experiences regarding host attitudes. Because many of the underlying evaluation questions remain open-ended, the broader expert framework maintains high flexibility and does not depend strictly on a fixed number of inputs. Furthermore, the study establishes a three-stage expert evaluation architecture that systematically converts individual tourist feedback on expected and realized social encounters into collective destination knowledge. By leveraging fuzzy logic and intelligent data analysis, the model effectively addresses the inherent ambiguity of subjective guest evaluations while accounting for individual psychological responses across both positive and negative travel experiences. Integrated within this architecture is a step-by-step predictive algorithm that estimates social environment loyalty levels for distinct visitor socioeconomic classes, offering destination managers and policymakers a flexible tool to construct strategic scenarios and refine their consumer value propositions. Finally, the empirical viability of the model was tested and validated using real-world data from 2,343 respondents across the V4 nations, demonstrating its practical application through multi-regional loyalty assessments. An example of estimation on three regions to derive the output estimate $Y(f)$ is illustrated. Looking ahead, the authors plan to develop dedicated software to support digital transformation and practical management of social environment loyalty across broader European Union destinations, alongside further enhancing the framework by integrating artificial intelligence and machine learning techniques for comparative analytical performance. The formal validation supports the reproducibility of the calculation and the use of the equations for bounded scenario analysis, while the residual and influence diagnostics require that the predictions be interpreted cautiously and that the regional scores remain descriptive rather than inferential regional effects.

As for future research, the authors plan to design innovative software for the practical management of innovative business models of digital transformation regarding the assessment of the influence of the external social environment on the formation of loyalty to the destination in different EU countries. And also, to continue this research by applying artificial intelligence technology and machine learning methods, after which compare the obtained results.

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