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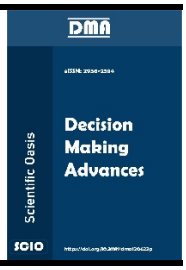

A Neutrosophic Expert Reputation Rating (ERERA) based Barrier Classification Model for the Sharing Economy

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ABSTRACT

This paper considers barriers to the development of the sharing economy from the perspective of actors who are directly faced with the challenges of running a business. An original barrier classification model referred to as the two-phase neutrosophic Expert REputation RAting (ERERA) is formulated. Uncertainties regarding severity estimations of barriers and reputation appraisals of decision analysts are addressed using type-2 neutrosophic numbers (T2NNs). In the first phase, neutrosophic ERERA differentiates the decision analysts by taking into account their reputation indicators and built-in trade-off parameters. In the second phase, this innovative barrier classifier determines the severity degrees of the barriers and categorizes them by taking into account the nature of the addressed problem. The number of intrinsic parameters of neutrosophic ERERA equals the number of reputation indicators plus classification parameters, thus making it flexible for real-life multi-criteria group decision-making applications. Based on research conducted in Serbia, a set of critical severity barriers is found. In-depth sensitivity analysis confirmed the stability of the initial classes produced by neutrosophic ERERA. Funding, pre-opening requirements, and familiarity should be regarded as critical severity barriers to the sharing economy adoption in Serbia.

1. Introduction

The sharing economy is one of the most significant global trends that is shaking the culture of ownership and the traditional, corporate-dominated economic models. According to Professor Arun Sundararajan, the author of the book "The Sharing Economy" [1], crowd-based capitalism "will stand

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alongside our 20th-century corporate model as one of the mainstream ways in which the world's economic activity is organized". He also foresees that in many industries, companies will transform into crowd-based platforms, shifting from selling products to offering services and experiences [2].

As acknowledged by European officials, the sharing economy or collaborative economy refers to business models where activities are facilitated by collaborative platforms that create an open marketplace for the temporary usage of goods or services often provided by private individuals [3]. The scope of the sharing economy includes activities providing access to various goods and services, such as accommodation, transport, consumer durables, labor, human capital, intellectual property, professional services, and finance [4]. Values in the sharing economy are created by the interaction of three actors, who are the backbone of the sharing economy ecosystem, common to all types of sharing activities. They are:

i. peer-service providers who offer skills, time, or assets;
ii. users of these services;
iii. collaborative platforms which enable peer-to-peer intermediations (that is, transactions between users and providers).

The figures show that the sharing economy has been dynamically developed over recent years. According to Statista Research Department, the total value of the global sharing economy in 2021 is estimated to be 113 billion U.S. dollars, and with projected growth at a rate of approximately 32 percent per year, it could reach 600 billion U.S. dollars by 2027. However, two facts should be highlighted. First, the spectacular revenues and the number of active participants predicted for the last decade proved to be too optimistic and are far from the current figures [5]. Second, the growth is mostly spread across the two economic sectors; transportation and hospitality are highly dependent on the revenue generation of flagship companies in those sectors, Uber and Airbnb.

Much less attention in the literature is paid to unsuccessful stories. Although it might seem that peer-to-peer exchanging platforms are promising since not as asset-heavy business models, many of them failed to scale up. Moreover, statistics show that 44% of sharing platforms fail after 5 years of operating, while only 10% stay active after 10 years [6]. Numerous barriers are preventing the development of a virtuous cycle of increasing demand, supply, and investments in the sharing economy and spreading it both in scope and scale. This paper deals with barriers to sharing economy growth, highlighting various aspects that platform operators should focus on when considering how to "play and stay" on the market.

From a conceptual perspective, there is a lack of studies offering a holistic view of barriers to sharing economy adoption, especially from a running-a-business viewpoint. Thus, the first aim of this study is to investigate what prevents the sharing economy from scaling up. More specifically, the paper is focused on the perspective of those actors who are faced with business development challenges using Serbia as a case study. The research questions addressed in this paper are the following:

i. What are the most influential barriers to the growth of the sharing economy, and which classes of severity do they belong to?
ii. Whether and to what extent does the level of competence of the decision analysts affect the obtained classes of barriers?

The second aim of the research is a barrier classification model proposal to support the sharing economy. The proposed barrier classifier for the sharing economy is referred to as the neutrosophic

Expert REputation RAting (ERERA) model. It is based on the multi-criteria group decision-making (MCGDM) approach [7,8]. Also, two-phase ERERA exploits type-2 neutrosophic numbers (T2NNs) [9,10] to account for uncertainties about barriers' severity estimation and decision analysts' reputation appraisals [11,12]. T2NNs [12,13] were widely employed in various MCGDM problems [14,15]. Its first phase aims to differentiate decision analysts by taking into account their reputation indicators and built-in trade-off parameters. It takes into account the reputation of decision analysts, so the output is thus more credible. Its second phase determines the severity degrees of the barriers and categorizes them into classes such as "critical severity barrier", "medium severity barrier", or "low severity barrier".

This research is structured as follows: Section 2 provides a review of barriers to sharing economy development and research gaps. Section 3 formulates the addressed problem. Section 4 presents the developed neutrosophic ERERA-based barrier classification model for the sharing economy. Section 5 provides the results and discussion. Section 6 presents the conclusions and implications.

2. Literature Review

As a disruptive socio-economic concept, the sharing economy has gained a huge interest among both the academic community and practitioners. To explore the literature on barriers to the sharing economy, other interchangeably used terms like “collaborative consumption”, “platform economy”, “crowd-based capitalism”, “peer-to-peer economy”, “digital matching firms”, and “product-service economy” were also included in the search. After reviewing numerous pieces of literature, summarized in Table 1, we generally observed that the most represented topic in the research on the future progress of the sharing economy is how to engage more people, and accordingly, what prevents people from participating. In this respect, there are a number of studies dealing with either consumers or peer-service providers (or both, the so-called “prosumers”), that is, their requirements, readiness, motivations, or disinterests for participation. Many of the resulting barriers are sociocultural.

At this point, some findings will be mentioned. For example, by interviewing experts and surveying consumers, study [16] revealed several obstacles to the sharing economy: desire to own, lack of trust in others, impractical and complicated procedures to provide access, fear of product unavailability, and hygiene concerns. Lack of efficacy and lack of economic benefits were identified as deterrents to collaborative consumption by an online survey in [17]. These barriers are further decomposed and analyzed in detail. The approach in [18] investigated barriers from the provider and the consumer sides. By analyzing data obtained through semi-structured interviews, they found and further explained nine relevant barriers: effort expectancy, exploitation, inflexibility, lack of trust, performance risk, physical risk, privacy risk, process risk, and undesired social interaction. Barriers to collaborative consumption from both consumers' and providers' perspectives were also identified in [19] through focus groups and interviews. The authors defined two groups of barriers: psychological and functional. The former consists of compatibility (under which the authors assume lifestyle, experience, social norms, etc.), contamination (physical contact), image (brand issues), and responsibility. The latter is related to complexity, value, and risk. After conducting two wide surveys and exploratory factor analysis, the study [20] singled out several demotivational factors for users, like effort expectancy, process risks, resource scarcity, and privacy protection. Yau & Mahn [21] subsumed barriers to becoming a sharing service user into five categories: information issues, low-cost efficiency, perceived risks, convenience issues, and negative attitude.

Table 1
Related studies

Source	Sector focus	Geospatial coverage	Perspective	Method used
Hazée et al. [19]	No	Belgium	Customers and peer service providers	Mixed-method qualitative approach (focus groups, interviews, and critical incident technique)
Hawlitschek et al. [20]	Yes, peer-to-peer rental service	University students from Karlsruhe, Germany	Peer-to-peer rental service users	Online survey and Exploratory factor analysis
Yau & Mahn [21]	Yes, car-sharing	German cities	Car-sharing users and one corporate manager	Qualitative strategy (in-depth interviews)
Calcagni et al. [22]	No	Santa Cruz, California, USA	Experts in the sharing economy theory and practice	Qualitative strategy (semi-structured interviews)
Revinova et al. [23]	No	Russia (Moscow and Krasnodar)	Students	Personal interviews
Jonek-Kowalska & Wolniak [24]	No	Polish cities	City authorities	Computer-assisted Web interview and statistical analysis
Retamal [26]	No	Southeast Asia cities (Hanoi, Bangkok and Metro Manila)	Sharing economy providers and a range of expert stakeholders	Personal interviews and social practice theory
May et al. [27]	No	City of Umeå, Sweden	Municipality employees and digital strategists from business and academia	Qualitative strategy (interviews and case study approach)
Lang et al. [28]	Yes, accommodation Airbnb platform	Without specific geo-area	Platform users	Survey with item scaling and statistical analysis
Govindan et al. [29]	Yes, Industrial manufacturing SMEs	India	Industrial managers	BWM and DEMATEL
Manzoor et al. [30]	Yes, Auto parts manufacturing SMEs	UK	Auto industry experts	BWM
This study	*No*	*Serbia (Belgrade)*	*Business/platform operators and supporting organizations*	*Neutrosophic ERERA-based barrier classification model*

When catalyzing sharing economy growth in a marketplace, prosumer uptake, although crucial, is, however, only one side of the story. From the business perspective, for the sharing economy to expand, many other issues of interest need to be addressed. These are the availability of resources

for the development and running of sharing platforms, or more generally, the overall business and regulatory environment.

As regards the literature, a few articles indicated this sort of barrier. For instance, Calcagni et al. [22] specified a range of economic barriers that many business-related questions pointed out, among which are the disruption effect on traditional industry, underestimation of labor, lack of regulations, and the dominance of some platforms over others. As found by Revinova et al. [23], insufficient business interest in the development of platforms in some sharing service areas like co-working and carsharing was found to be relevant. Apart from institutional and legal requirements, universal access to digital infrastructure and possible lack of resources were indicated as the obstacles to sharing economy development by [24]. Both citizens and city authorities took part in their research to come up with these barriers. Studies [25,26] observed several problems that "sustainable product-service system" oriented businesses (as is the sharing economy) face. These were related to investments needed, dependence on cooperation with external actors, and potential exposure of internal business data. Some authors [27,28] pointed to the network effect or network capabilities as something that might hinder the rise of the sharing economy. By that, they meant the necessity of having a network of actors and assets for the reliable service of platform operators.

Besides the literature on barriers being mostly focused on consumers and peer-service providers, evaluating barriers is an uncovered field. We are aware of only two sources providing many-sided views on the barriers to the sharing economy by now. Combining knowledge from literature and experts' opinions, Govindan et al. [29] defined a detailed list of items belonging to four major categories: economic, stakeholder, social, and technical barriers. Using BWM and DEMATEL, they shortened the initial list and thereafter ranked them by their influence. Their article was followed by work with an equally rich list of barriers, subsumed into organizational, financial, information, and technology/technical related ones [30]. Using BWM and collecting experts' opinions, the authors determined the influence of each barrier. Goyal et al. [31] aimed to perform an assessment of sharing economy alternatives in the Metaverse. Differently, our work considers barriers to the development of the sharing economy from the perspective of actors who are directly faced with the challenges of running a business.

In sum, after a thorough review of the literature on barriers to the sharing economy, we observed the following gaps:

i. The findings are mainly produced from a survey of users, peer-service providers, or other stakeholders like authorities or traditional industry managers, while limited understanding remains regarding the barriers faced by sharing economy business representatives, foremost platform operators.
ii. A few attempts have been made to provide an integrated methodological view under uncertainty, where the whole spectrum of barriers, differing in nature, would be evaluated to determine the influence of each.

3. Problem Definition

3.1 Context Definition

Apart from being a complex concept in its essence, the sharing economy is also a challenging topic of research. This especially goes for the lack of data and records in official sources of data, both at the national, regional, and worldwide levels. Sharing economy platforms and businesses can appear in any given industry and do not fit in standard classification systems (like standard industrial classification or standard occupational classification) [32]. Sharing economy platform operators are

often registered outside the economic field where they are recognized. For example, from a general perspective, Uber is seen as a transport service provider, but in official records, it can be found under the technology sector and industry software application. This study examines sharing economy perspectives in Serbia, which is, for the time being, a market that has yet to reach a higher level of sharing economy presence. Serbia offers favorable conditions for the sharing economy due to its high adoption of ICT among youth and widespread use of social media. The increasing number of e-commerce users supports digital transactions, while a growing start-up ecosystem nurtures sharing economy businesses. Moreover, Serbia's development of innovation support through accelerators and incubators, alongside a strategic emphasis on digitalization and technological entrepreneurship, further enhances opportunities for sharing economy growth. Recognizing the potential of the sharing economy, a Serbian major scientific institution recently granted a three-year research project in this field, which provided resources to collect data on existing sharing economy platforms and supporting organizations, through direct market research.

Only half of the identified sharing economy platforms can be found in official business records in Serbia, dominantly in the information and communication sector, as well as professional, scientific, innovative, and technical activities [33]. This limits the use of official sources to identify actors to sample and gather necessary data for barriers assessment. Without official records, we need to rely on research of web sources and particularly social media, where these actors are most present, but information is unreliable and scarce. This poses difficulties in making contact with potential respondents, which is further accentuated by their reluctance to participate.

A set of barriers was compiled based on the literature review and inputs obtained from the workshop held in September 2022. The workshop was used to collect experience from various stakeholders engaged in the sharing economy. In total, 20 representatives participated in the workshop. Representatives from academia (sharing economy researchers), platform operators, peer-service providers, and start-up support organizations expressed their experiences and views on the state of play and pointed out what hinders the development of the sharing economy in Serbia.

Throughout two rounds of discussion, the list of barriers obtained from the literature was refined. The final list was made so that the barriers were relatively universal; that is, they apply to different sectors of the sharing economy. Also, a wider context was considered as what hindered the adoption of innovative products and services, or what business start-ups encountered in general in Serbia.

3.2. List of Barriers

Barriers are structured to represent two major categories. The first is related to “business infrastructure”, which includes a range of monetary and non-monetary, pre-opening, and post-opening resources required. Once the sharing economy platform begins to operate, achieving and sustaining a critical mass of participants for stable supply and demand is crucial for business survival. Thus, the second category of barriers is about the “power of persistence” or the power of a network, where issues preventing from growing the number of peer-service providers and consumers are included. In total, the list consists of 13 items (Table 2).

Table 2
List of barriers to the sharing economy

Categories	Barriers	Explanations	Supporting literature
Business infrastructure	Business plan or business strategy	Insufficient experience and lack of competencies in creating business plans/strategies for digital matching firms	Workshop
	Technology	Lack of advanced technology like Internet of Things, blockchain, and tools to process, analyze, and store a large amount of daily produced and collected data	Hawlitschek et al. [20], Govindan et al. [29]
	Funding	Lack of sustainable funding to support more startup ideas; Insufficient state budget allocations to stimulate the sharing economy	Workshop, Hawlitschek et al. [20]
	Data managing	Insufficient use of data and analytics for making strategic decisions and fulfilling customer requirements in real-time	Govindan et al. [29]
	Visibility	Limited budget to continue work on marketing (investments in promotion, advertising, and running campaigns)	
	Pre-opening requirements	Time and cost-consuming activities like buying equipment, building a sharing platform (mobile app and website), procurement of licenses and permits, insurance costs, legal and accounting/consulting fees, staffing, etc.	Workshop, Govindan et al. [29]
	Running and maintaining the platform	Shortage of IT and engineering talent for building a persistent team needed to continually evolve the platform so that it stays competitive and can be leaned upon	Workshop, Govindan et al. [29]
	Legal aspects	Unresolved legal status and competencies of the peer-service provider and the platform operators.	Workshop, May et al. [27], Govindan et al. [29]
The power of persistence	Trust	Low level of trust between peers or in a platform (for example, lack of transparency in the reputation system), and inadequate protection of consumers and providers	Hazée et al. [19], Hawlitschek et al. [20], Yao & Mahn [21], Calcagni et al. [22], May et al. [27], Lang et al. [28]
	Quality of service	Erosion of the quality of service (produced by peer providers and the quality of interaction between peers, provided by the platform) stemming from matching supply and demand	Workshop, Yao & Mahn [21], May et al. [27], Govindan et al. [29]
	Readiness to change	Low level of readiness to shift in mindset and behavior from owning to accessing	Calcagni et al. [22], May et al. [27], Govindan et al. [29]
	Familiarity	Low knowledge about SE, its benefits, and how to participate	Workshop, Hazée et al. [19], Yao & Mahn [21], May et al. [27], Govindan et al. [29],
	Value co-creation	Low level of collaboration with consumers and providers to collect their feedback, experience, perspectives, and fresh ideas to enable value co-creation	Hazée et al. [19], Govindan et al. [29]

4. Neutrosophic ERERA-based Barrier Classification Model

Notations used in the neutrosophic ERERA-based barrier classifier are given in Appendix A. Let us denote by $h \geq 2$ the number of barriers; $m \geq 2$ is the number of decision analysts who possess the skills and knowledge to evaluate the severity of the existing barriers; $\mathbb{B} = \{\mathbb{B}_1, \mathbb{B}_2, \ldots, \mathbb{B}_l, \ldots, \mathbb{B}_h\}$ is the set of barriers; and $\mathbb{D} = \{\mathbb{D}_1, \mathbb{D}_2, \ldots, \mathbb{D}_c, \ldots, \mathbb{D}_m\}$ is the set of decision analysts. The neutrosophic framework for barrier classification is formulated as follows (Figure 1):

Phase 1: Neutrosophic ERERA.

Step 1.1. *Select reputation indicators of the decision analysts.*

Let us denote by $n \geq 2$ the number of indicators to differentiate the reputation of the decision analysts, with $\mathbb{I} = \{\mathbb{I}_1, \mathbb{I}_2, \ldots, \mathbb{I}_k, \ldots, \mathbb{I}_n\}$ as the set of reputation indicators.

Step 1.2. *Construct the T2NN reputation matrix*:

$$\tilde{\mathrm{Y}} = \left[\tilde{Y}_k^c\right]_{n\times m} = \begin{array}{c} \\ \mathbb{I}_1 \\ \vdots \\ \mathbb{I}_k \\ \vdots \\ \mathbb{I}_n \end{array} \begin{array}{c} \begin{array}{cccccc} \mathbb{D}_1 & \cdots & \mathbb{D}_c & \cdots & \mathbb{D}_m \end{array} \\ \begin{bmatrix} \tilde{Y}_1^1 & \cdots & \tilde{Y}_1^c & \cdots & \tilde{Y}_1^m \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \tilde{Y}_k^1 & \cdots & \tilde{Y}_k^c & \cdots & \tilde{Y}_k^m \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \tilde{Y}_n^1 & \cdots & \tilde{Y}_n^c & \cdots & \tilde{Y}_n^m \end{bmatrix} \end{array} \tag{1}$$

where $\tilde{Y}_k^c$ is the T2NN representing a (self-)appraisal of the reputation under the indicator $\mathbb{I}_k$ given by the decision analyst $\mathbb{D}_c$.

Step 1.3. *Define the T2NN aggregated reputation matrix*:

$$\begin{aligned} \tilde{A}^c &= T2NNWA_{\xi}\left(\tilde{Y}_1^c, \tilde{Y}_2^c, ..., \tilde{Y}_k^c, ..., \tilde{Y}_n^c\right) = \bigoplus_{k=1}^{n} \xi_k \tilde{Y}_k^c \\ &= \begin{bmatrix} \left(1 - \prod_{k=1}^{n}\left(1 - \mathcal{P}_{\mathcal{P}_{\tilde{Y}_k^c}}\right)^{\xi_k}, 1 - \prod_{k=1}^{n}\left(1 - \mathcal{P}_{\mathcal{J}_{\tilde{Y}_k^c}}\right)^{\xi_k}, 1 - \prod_{k=1}^{n}\left(1 - \mathcal{P}_{\mathcal{N}_{\tilde{Y}_k^c}}\right)^{\xi_k}\right), \\ \left(\prod_{k=1}^{n}\left(\mathcal{J}_{\mathcal{P}_{\tilde{Y}_k^c}}\right)^{\xi_k}, \prod_{k=1}^{n}\left(\mathcal{J}_{\mathcal{J}_{\tilde{Y}_k^c}}\right)^{\xi_k}, \prod_{k=1}^{n}\left(\mathcal{J}_{\mathcal{N}_{\tilde{Y}_k^c}}\right)^{\xi_k}\right), \\ \left(\prod_{k=1}^{n}\left(\mathcal{N}_{\mathcal{P}_{\tilde{Y}_k^c}}\right)^{\xi_k}, \prod_{k=1}^{n}\left(\mathcal{N}_{\mathcal{J}_{\tilde{Y}_k^c}}\right)^{\xi_k}, \prod_{k=1}^{n}\left(\mathcal{N}_{\mathcal{N}_{\tilde{Y}_k^c}}\right)^{\xi_k}\right) \end{bmatrix}, \quad c = 1, 2, \ldots, m \end{aligned} \tag{2}$$

where $\tilde{A}^c$ is the T2NN aggregated reputation of the decision analyst $\mathbb{D}_c$ under all indicators; and $\xi_k \in [0, 1]$ $(k = 1, 2, \ldots, n)$ is the trade-off parameter of the reputation indicator $\mathbb{I}_k$ with $\sum_{k=1}^{n} \xi_k = 1$.

The number of intrinsic parameters of neutrosophic ERERA equals the number of reputation indicators *n*.

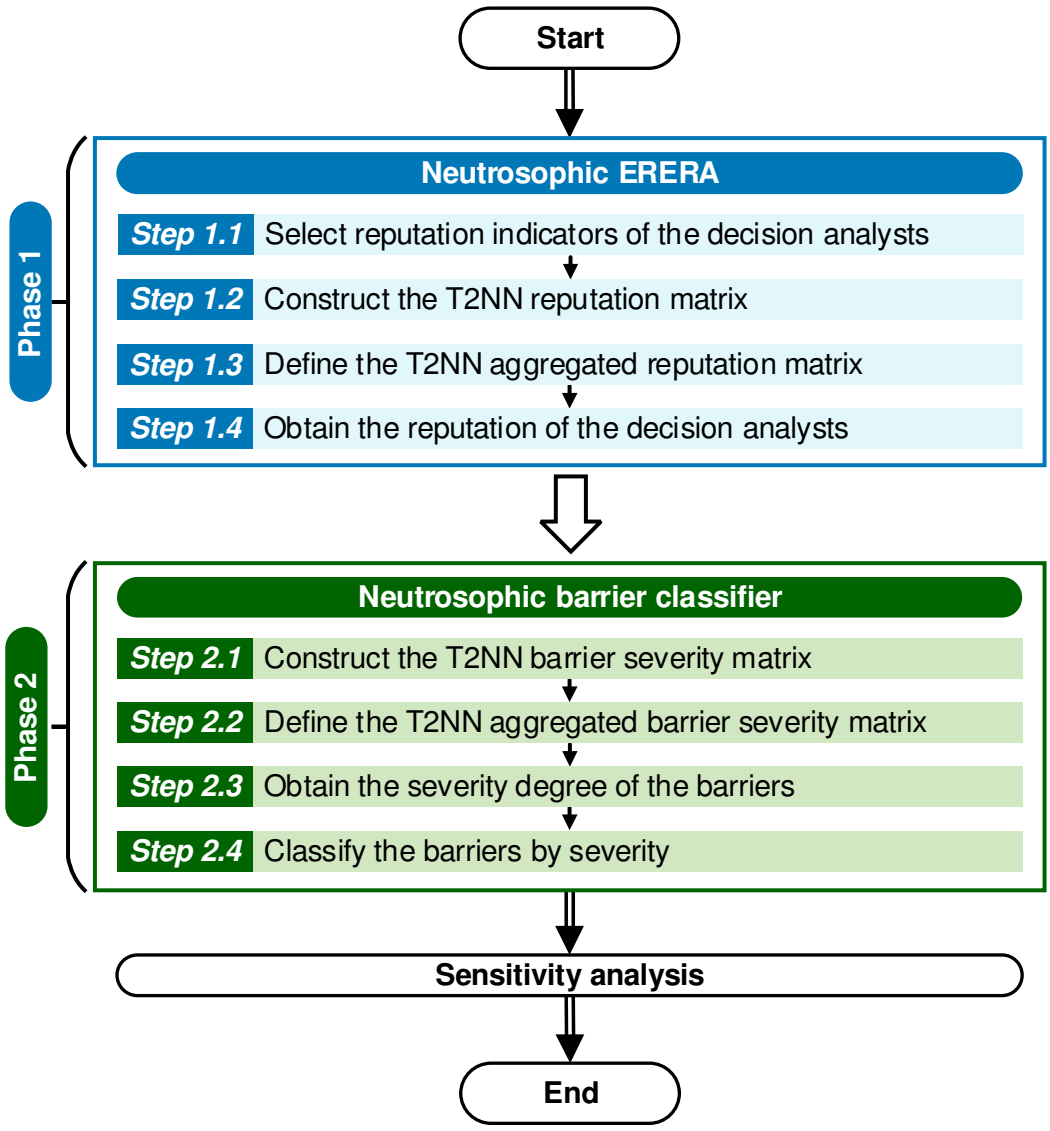

Fig. 1. Neutrosophic ERERA-based model for barrier classification

Step 1.4. *Obtain the reputation of the decision analysts:*

$$R^c = \mathbb{S}\left(\tilde{A}^c\right) \Big/ \sum_{t=1}^{m} \mathbb{S}\left(\tilde{A}^t\right), \ \ c = 1, 2, \ldots, m, \tag{3}$$

where $R = \left(R^1, R^2, \ldots, R^c, \ldots, R^m\right)^T$ represents the reputation vector of the decision analysts, R^c $\left(c = 1, 2, \ldots, m\right)$ is the reputation of the decision analyst $\mathbb{D}_c$, with $R^c \in [0, 1]$ and $\sum_{c=1}^{m} R^c = 1$. In Eq. (3), the score function $\mathbb{S}\left(\tilde{A}^c\right)$ $\left(c = 1, 2, \ldots, m\right)$ is used for deneutrosophication of the T2NN aggregated reputation of the decision analyst $\mathbb{D}_c$ as follows:

$$\mathbb{S}\left(\tilde{A}^c\right) = \left(8 + \mathcal{P}_{\mathcal{P}_{\tilde{A}^c}} + 2\mathcal{P}_{\mathcal{I}_{\tilde{A}^c}} + \mathcal{P}_{\mathcal{N}_{\tilde{A}^c}} - \mathcal{I}_{\mathcal{P}_{\tilde{A}^c}} - 2\mathcal{I}_{\mathcal{I}_{\tilde{A}^c}} - \mathcal{I}_{\mathcal{N}_{\tilde{A}^c}} - \mathcal{N}_{\mathcal{P}_{\tilde{A}^c}} - 2\mathcal{N}_{\mathcal{I}_{\tilde{A}^c}} - \mathcal{N}_{\mathcal{N}_{\tilde{A}^c}}\right) \Big/ 12, \ \ c = 1, 2, \ldots, m \tag{4}$$

Stage 2: Neutrosophic barrier classifier.

Step 2.1. *Construct the T2NN barrier severity matrix:*

$$\tilde{\mathrm{X}}=\left[\tilde{X}_l^c\right]_{h\times m}=\begin{array}{c} \\ \mathbb{B}_1 \\ \vdots \\ \mathbb{B}_l \\ \vdots \\ \mathbb{B}_h \end{array}\begin{array}{c} \begin{array}{cccccc} \mathbb{D}_1 & \cdots & \mathbb{D}_c & \cdots & \mathbb{D}_m \end{array} \\ \begin{bmatrix} \tilde{X}_1^1 & \cdots & \tilde{X}_1^c & \cdots & \tilde{X}_1^m \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \tilde{X}_l^1 & \cdots & \tilde{X}_l^c & \cdots & \tilde{X}_l^m \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \tilde{X}_h^1 & \cdots & \tilde{X}_h^c & \cdots & \tilde{X}_h^m \end{bmatrix} \end{array} \tag{5}$$

where $\tilde{X}_l^c$ is the T2NN denoting the linguistic severity estimation of the barrier $\mathbb{B}_l$ given by the decision analyst $\mathbb{D}_c$. The T2NN scale from Table 3 can be employed by decision analysts for providing severity estimations of the barriers.

Table 3
T2NN scale for estimating the severity of the barriers

Linguistic terms	Type-2 neutrosophic numbers
Extremely-low severity (ELS)	[(0.05,0.1,0.05), (0.8,0.95,0.95), (0.8,0.9,0.8)]
Very-low severity (VLS)	[(0.15,0.2,0.1), (0.7,0.85,0.85), (0.6,0.8,0.7)]
Low severity (LS)	[(0.35,0.3,0.25), (0.6,0.7,0.8), (0.5,0.75,0.65)]
Medium-low severity (MLS)	[(0.45,0.35,0.35), (0.5,0.65,0.55), (0.4,0.65,0.55)]
Medium severity (MS)	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]
Medium-high severity (MHS)	[(0.6,0.55,0.55), (0.25,0.4,0.45), (0.25,0.45,0.35)]
High severity (HS)	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]
Very-high severity (VHS)	[(0.8,0.75,0.8), (0.15,0.15,0.25), (0.1,0.15,0.2)]
Extremely-high severity (EHS)	[(0.95,0.9,0.95), (0.1,0.1,0.05), (0.05,0.05,0.1)]

Step 2.2. *Define the T2NN aggregated barrier severity matrix*:

$$\begin{aligned}\tilde{Z}_l &= T2NNWA_R\left(\tilde{X}_1^c,\tilde{X}_2^c,...,\tilde{X}_l^c,...,\tilde{X}_h^c\right)=\overset{m}{\underset{c=1}{\oplus}}R^c\,\tilde{X}_l^c \\ &=\left[\begin{array}{l}\left(1-\prod_{c=1}^{m}\left(1-\mathcal{P}_{\mathcal{P}_{\tilde{X}_l^c}}\right)^{R^c},1-\prod_{c=1}^{m}\left(1-\mathcal{P}_{\mathcal{J}_{\tilde{X}_l^c}}\right)^{R^c},1-\prod_{c=1}^{m}\left(1-\mathcal{P}_{\mathcal{N}_{\tilde{X}_l^c}}\right)^{R^c}\right), \\ \left(\prod_{c=1}^{m}\left(\mathcal{J}_{\mathcal{P}_{\tilde{X}_l^c}}\right)^{R^c},\prod_{c=1}^{m}\left(\mathcal{J}_{\mathcal{J}_{\tilde{X}_l^c}}\right)^{R^c},\prod_{c=1}^{m}\left(\mathcal{J}_{\mathcal{N}_{\tilde{X}_l^c}}\right)^{R^c}\right), \\ \left(\prod_{c=1}^{m}\left(\mathcal{N}_{\mathcal{P}_{\tilde{X}_l^c}}\right)^{R^c},\prod_{c=1}^{m}\left(\mathcal{N}_{\mathcal{J}_{\tilde{X}_l^c}}\right)^{R^c},\prod_{c=1}^{m}\left(\mathcal{N}_{\mathcal{N}_{\tilde{X}_l^c}}\right)^{R^c}\right)\end{array}\right],\ l=1,2,\ldots,h\end{aligned} \tag{6}$$

where $\tilde{Z}_l$ is the T2NN aggregated severity of the barrier $\mathbb{B}_l$ under all decision analysts.

Step 2.3. *Obtain the severity degree of the barriers*:

$$G_l=\left(\mathbb{S}\left(\tilde{Z}_l\right)-\min_{1\le l\le h}\mathbb{S}\left(\tilde{Z}_l\right)\right)\Big/\left(\max_{1\le t\le h}\mathbb{S}\left(\tilde{Z}_t\right)-\min_{1\le t\le h}\mathbb{S}\left(\tilde{Z}_t\right)\right),\ l=1,2,\ldots,h \tag{7}$$

where $G_l \in [0,1]\,(l=1,2,\ldots,h)$ is the severity degree of the barrier $\mathbb{B}_l$.

Step 2.4. *Classify the barriers by severity*.

The barrier $\mathbb{B}_l\,(l=1,2,\ldots,h)$ is classified as:

(*i*) "critical severity barrier" if $G_l > \theta_2$

(*ii*) "medium severity barrier" if $\theta_1 < G_l \le \theta_2$ (8)

(*iii*) "low severity barrier" if $G_l \le \theta_1$

where $\theta_1, \theta_2 \in (0,1)$ are the classification parameters, with $\theta_1 < \theta_2$. A decision-maker defines the values of θ_1 and θ_2 by taking into account the nature of the addressed problem.

The neutrosophic ERERA (i.e., Stage 1) has the complexity of $O(mn)+2\cdot O(m)$, where n is the number of indicators to differentiate the reputation and m is the number of decision analysts. Specifically, the construction of the T2NN reputation matrix has a complexity of $O(nm)$, followed by the determination of the T2NN aggregated reputation matrix with a complexity of $O(m)$. Then, the complexity of obtaining the reputation of the decision analysts is $O(m)$. Adding these entities gives the complexity as $O(mn)+2\cdot O(m)$. The neutrosophic barrier classifier (i.e., Stage 2) has the complexity of $O(hm)+2\cdot O(h)+h$, where h is the number of barriers. Specifically, the construction of the T2NN barrier severity matrix has a complexity of $O(hm)$, followed by the determination of the T2NN aggregated barrier severity matrix with a complexity of $O(h)$. The last two steps deal with the calculation of barrier severity degrees and their sorting into classes. Their complexity is $h+O(h)$. Adding these entities gives the complexity as $O(hm)+2\cdot O(h)+h$. As a result, the complexity of the neutrosophic ERERA-based barrier classification model is given by $O(mn)+O(hm)+2\cdot(O(m)+O(h))+h$.

5. Results and Discussion

5.1 Experimental Results

Stage 1: Neutrosophic ERERA.

Step 1.1. Four reputation indicators were used to differentiate the reputation of the decision analysts; that is, "years of experience" $(\mathbb{I}_1)$, "sharing economy expertise" $(\mathbb{I}_2)$, "sharing economy domain impact" $(\mathbb{I}_3)$, and "qualifications" $(\mathbb{I}_4)$. The four T2NN scales are proposed in Table 4 to distinguish decision analysts under the selected set of the reputation indicators $\mathbb{I}=\{\mathbb{I}_1,\mathbb{I}_2,\mathbb{I}_3,\mathbb{I}_4\}$. In Table 4, EQF indicates a level of qualifications in accordance with the European Classification Framework.

Step 1.2. We exploited contacts made during the workshop and approached those who were familiar with the concept of the sharing economy and had experience in developing business in such a setting. The targeted group of stakeholders $\mathbb{D}=\{\mathbb{D}_1,\mathbb{D}_2,\ldots,\mathbb{D}_{10}\}$ were directly contacted during January and February 2023 and asked to appraise their reputation under the selected indicators using the scales from Table 4. Detailed information on the decision analysts and collected reputation appraisals under four indicators are given in Table 5.

Table 4
Five-point T2NN reputation scales to differentiate decision analysts under the indicators

Reputation indicators				Type-2 neutrosophic numbers
$\mathbb{I}_1$: Years of experience	$\mathbb{I}_2$: Sharing economy expertise	$\mathbb{I}_3$: Sharing economy domain impact	$\mathbb{I}_4$: Qualifications	
$5<$	Poor	Negligible	EQF - 4	[(0.05,0.1,0.05),(0.8,0.95,0.95),(0.8,0.9,0.8)]
$[5,10)$	Fair	Minor	EQF - 5	[(0.35,0.3,0.25),(0.6,0.7,0.8),(0.5,0.75,0.65)]
$[10,15)$	Good	Moderate	EQF - 6	[(0.5,0.45,0.5),(0.35,0.55,0.5),(0.35,0.55,0.45)]
$[15,20)$	Very good	Significant	EQF - 7	[(0.7,0.65,0.65),(0.2,0.3,0.4),(0.2,0.25,0.3)]
≥ 20	Excellent	Major	EQF - 8	[(0.95,0.9,0.95),(0.1,0.1,0.05),(0.05,0.05,0.1)]

Table 5
Detailed information on the decision analysts and the appraisals of the reputation

Decision analysts	Type of involvement	Sharing economy (SE) area	Gender	Reputation indicators			
				$\mathbb{I}_1$: Years of experience	$\mathbb{I}_2$: SE expertise	$\mathbb{I}_3$: SE domain impact	$\mathbb{I}_4$: Qualific.
$\mathbb{D}_1$	SE platform operator	Mobility (bike sharing)	Male	10	Excellent	Moderate	EQF - 5
$\mathbb{D}_2$	SE platform operator	On-demand services (delivery)	Male	15	Good	Moderate	EQF - 5
$\mathbb{D}_3$	SE platform operator	On-demand services (cleaning)	Female	7	Very good	Major	EQF - 6
$\mathbb{D}_4$	SE platform operator	Coworking (shared workplaces)	Female	2	Good	Moderate	EQF - 6
$\mathbb{D}_5$	SE platform operator	Mobility (parking sharing)	Male	15	Very good	Moderate	EQF - 8
$\mathbb{D}_6$	SE platform developer	Mobility (ridesharing)	Female	3	Very good	Moderate	EQF - 6
$\mathbb{D}_7$	Innovation development specialist	Start-ups and tech companies	Male	5	Good	Moderate	EQF - 8
$\mathbb{D}_8$	SE platform developer	Mobility (ridesharing)	Male	3	Fair	Moderate	EQF - 6
$\mathbb{D}_9$	SE platform operator	Consumer durable goods	Female	3	Good	Moderate	EQF - 6
$\mathbb{D}_{10}$	SE platform operator	Crowdfunding	Male	6	Excellent	Moderate	EQF - 6

The T2NN reputation matrix $\left[\tilde{Y}_k^c\right]_{4\times 10}$ is provided in Table B.1 in Appendix B. It was constructed using Eq. (1) based on the four T2NN reputation scales (Table 4) and decision analysts' appraisals of their reputation (Table 5).

Step 1.3. In the explored context, neutrosophic ERERA has four intrinsic parameters. Thus, the trade-off parameter ξ_1 denotes the significance of the indicator "years of experience" $(\mathbb{I}_1)$, ξ_2 is the importance of the indicator "sharing economy expertise" $(\mathbb{I}_2)$, ξ_3 is the impact of the indicator

"sharing economy domain impact" $(\mathbb{I}_3)$, and ξ_4 is the significance of the indicator "qualifications" $(\mathbb{I}_4)$. In the base case scenario, it was presumed that all indicators were equally important when determining the reputation of the decision analysts; that is, $\xi_1=\xi_2=\xi_3=\xi_4=0.25$ to meet the condition $\xi_1+\xi_2+\xi_3+\xi_4=1$. Table 6 gives the T2NN aggregated reputation matrix. It was defined using Eq. (2) based on the T2NN reputation matrix (Table B.1) and the presumed importance values of the indicators. For instance, the T2NN aggregated reputation of the decision analyst $\mathbb{D}_3$ under all indicators was determined as:

$$\tilde{A}^3=\begin{bmatrix}\Big(1-\big((1-0.5)(1-0.7)(1-0.95)(1-0.5)\big)^{0.25}, 1-\big((1-0.45)(1-0.65)(1-0.9)(1-0.45)\big)^{0.25},\\ 1-\big((1-0.5)(1-0.65)(1-0.95)(1-0.5)\big)^{0.25}\Big),\\ \Big((0.35\cdot0.2\cdot0.1\cdot0.35)^{0.25},(0.55\cdot0.3\cdot0.1\cdot0.55)^{0.25},(0.5\cdot0.4\cdot0.05\cdot0.5)^{0.25}\Big),\\ \Big((0.35\cdot0.2\cdot0.05\cdot0.35)^{0.25},(0.55\cdot0.25\cdot0.05\cdot0.55)^{0.25},(0.45\cdot0.3\cdot0.1\cdot0.45)^{0.25}\Big)\end{bmatrix}$$

$$=\big[(0.7525,0.6792,0.7428),(0.2225,0.3086,0.2659),(0.1871,0.2480,0.2792)\big].$$

Table 6
T2NN aggregated reputation matrix

Decision analysts	T2NN aggregated reputations
$\mathbb{D}_1$	[(0.6998, 0.6185, 0.6888), (0.2928, 0.3815, 0.3162), (0.2352, 0.3264, 0.3387)]
$\mathbb{D}_2$	[(0.5301, 0.4782, 0.4939), (0.3482, 0.5020, 0.5318), (0.3327, 0.4880, 0.4458)]
$\mathbb{D}_3$	[(0.7525, 0.6792, 0.7428), (0.2225, 0.3086, 0.2659), (0.1871, 0.2480, 0.2792)]
$\mathbb{D}_4$	[(0.4130, 0.3779, 0.4130), (0.4304, 0.6305, 0.5870), (0.4304, 0.6221, 0.5196)]
$\mathbb{D}_5$	[(0.6591, 0.6081, 0.6174), (0.2300, 0.3491, 0.4229), (0.2300, 0.3045, 0.3320)]
$\mathbb{D}_6$	[(0.4834, 0.4444, 0.4631), (0.3742, 0.5419, 0.5552), (0.3742, 0.5108, 0.4695)]
$\mathbb{D}_7$	[(0.5599, 0.5088, 0.5427), (0.3043, 0.4727, 0.4729), (0.3043, 0.4516, 0.4066)]
$\mathbb{D}_8$	[(0.3732, 0.3393, 0.3503), (0.4924, 0.6697, 0.6602), (0.4705, 0.6722, 0.5696)]
$\mathbb{D}_9$	[(0.4130, 0.3779, 0.4130), (0.4304, 0.6305, 0.5870), (0.4304, 0.6221, 0.5196)]
$\mathbb{D}_{10}$	[(0.6998, 0.6185, 0.6888), (0.2928, 0.3815, 0.3162), (0.2352, 0.3264, 0.3387)]

Step 1.4. The reputation vector of the decision analysts is shown in Figure 2. It was obtained using Eq. (3) based on the T2NN aggregated reputation matrix (Table 6). According to Figure 2, neutrosophic ERERA allocated the highest reputation of $R^3=0.1319$ to the third decision analyst.

Stage 2: Neutrosophic barrier classifier.

Step 2.1. First, the final list of barriers to the sharing economy consisting of 13 items (Table 2) was used to define the set of barriers as $\mathbb{B}=\{\mathbb{B}_1,\mathbb{B}_2,\ldots,\mathbb{B}_{13}\}$. Second, the targeted group of decision analysts expressed their severity estimations of the barriers regarding the sharing economy adoption in Serbia using the scale from Table 3. The collected linguistic estimations under 13 barriers are provided in Table B.2. Third, the T2NN barrier severity matrix $\left[\tilde{X}_l^c\right]_{13\times10}$, given in Table B.3, was constructed using Eq. (5) based on the neutrosophic scale for estimating a barrier severity (Table 3) and the linguistic estimations provided by 10 decision analysts (Table B.2).

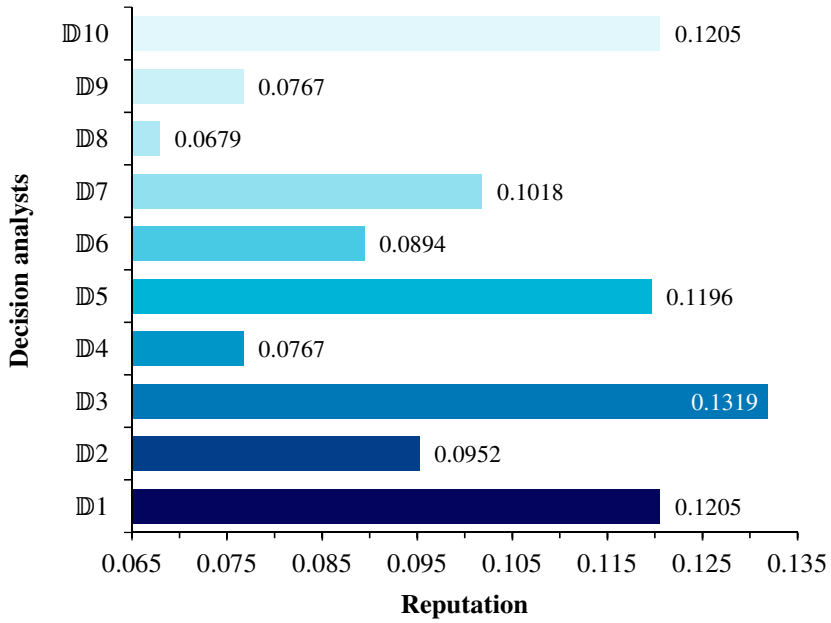

Fig. 2. Reputation of the decision analysts obtained by neutrosophic ERERA

Step 2.2. Table 7 gives the T2NN aggregated barrier severity matrix. It was defined using Eq. (6) based on the T2NN barrier severity matrix (Table B.3) and the reputation vector from Figure 2. For instance, the T2NN aggregated severity of the barrier "data managing" $(\mathbb{B}_4)$ under all decision analysts was determined as:

$$\tilde{Z}_4 = \begin{bmatrix} \left(1-(1-0.7)^{0.1205}(1-0.95)^{0.0952}(1-0.95)^{0.1319}(1-0.8)^{0.0767}\cdots(1-0.5)^{0.1205},\right. \\ 1-(1-0.65)^{0.1205}(1-0.9)^{0.0952}(1-0.9)^{0.1319}(1-0.75)^{0.0767}\cdots(1-0.45)^{0.1205}, \\ \left.1-(1-0.65)^{0.1205}(1-0.95)^{0.0952}(1-0.95)^{0.1319}(1-0.8)^{0.0767}\cdots(1-0.5)^{0.1205}\right), \\ \left(0.2^{0.1205}\cdot 0.1^{0.0952}\cdot 0.1^{0.1319}\cdot 0.15^{0.0767}\cdots\cdot 0.35^{0.1205}, 0.3^{0.1205}\cdot 0.1^{0.0952}\cdot 0.1^{0.1319}\right. \\ \left.\cdot 0.15^{0.0767}\cdots\cdot 0.55^{0.1205}, 0.4^{0.1205}\cdot 0.05^{0.0952}\cdot 0.05^{0.1319}\cdot 0.25^{0.0767}\cdots\cdot 0.5^{0.1205}\right) \\ 0.2^{0.1205}\cdot 0.05^{0.0952}\cdot 0.05^{0.1319}\cdot 0.1^{0.0767}\cdots\cdot 0.35^{0.1205}, 0.25^{0.1205}\cdot 0.05^{0.0952}\cdot 0.05^{0.1319} \\ \cdot 0.15^{0.0767}\cdots\cdot 0.55^{0.1205}, 0.3^{0.1205}\cdot 0.1^{0.0952}\cdot 0.1^{0.1319}\cdot 0.2^{0.0767}\cdots\cdot 0.45^{0.1205} \end{bmatrix}$$

$$= \left[(0.7715,\ 0.7027,\ 0.7519), (0.2014,\ 0.2662,\ 0.2655), (0.1645,\ 0.2188,\ 0.2586)\right].$$

Step 2.3. The severity degrees of the barriers were obtained using Eq. (7) based on the T2NN aggregated barrier severity matrix (Table 7). The obtained values are shown in Figure 3.

Step 2.4. Neutrosophic barrier classifier has two intrinsic parameters; that is, the first classification parameter θ_1 and the second classification parameter θ_2. First, it was defined that $\theta_1 = 0.5$ and $\theta_2 = 0.8$ (Figure 3). Then, the barriers were separated into three classes using the classification rules defined in Eq. (8) based on their severity degrees. The initial classes are provided in Table 7. Critical severity barriers for the sharing economy development in Serbia are "funding" $(\mathbb{B}_3)$, "data managing" $(\mathbb{B}_4)$, "pre-opening requirements" $(\mathbb{B}_6)$, and "familiarity" $(\mathbb{B}_{12})$. However, "visibility" $(\mathbb{B}_5)$, "legal aspects" $(\mathbb{B}_8)$, "quality of service" $(\mathbb{B}_{10})$, and "readiness to

change" $(\mathbb{B}_{11})$ are designated as medium severity barriers. Finally, the barriers $\mathbb{B}_1, \mathbb{B}_2, \mathbb{B}_7, \mathbb{B}_9,$ and $\mathbb{B}_{13}$ are denoted as low severity barriers.

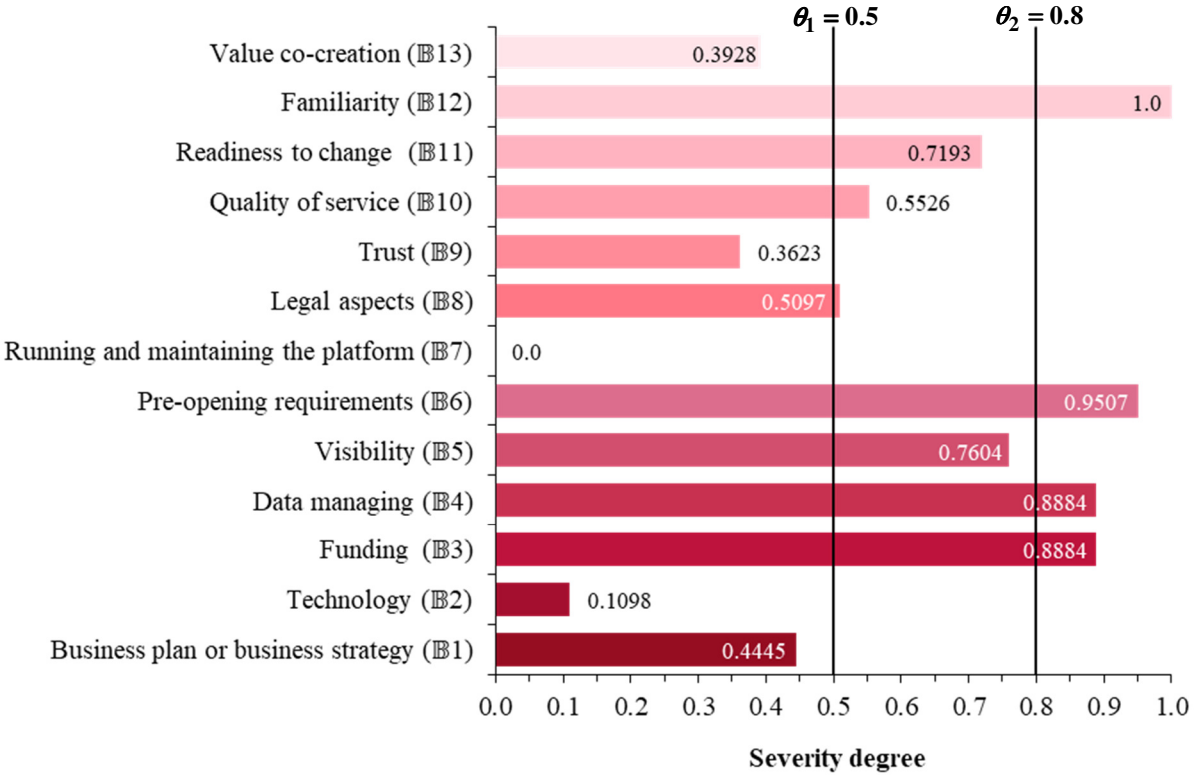

Fig. 3. Severity degrees of the barriers and the classification parameters

5.2. Sensitivity Analysis

The sensitivity analysis to changes in the reputation of the decision analysts was performed to explore the stability of the initial barrier classes (Table 7). Reputation vector scenarios were simulated by reducing the reputation of the most reputable decision analysts according to neutrosophic ERERA while adapting (that is, enlarging) the reputation of the others as follows:

$$\bar{R}^t = (1-\lambda)R^t \tag{9}$$

$$\bar{R}^c = R^c\left(1-\bar{R}^t\right)\Big/\left(1-R^t\right),\ c=1,2,\ldots,m \,|\, c\neq t \tag{10}$$

where R^t denotes the reputation of the most reputable decision analysts $\mathbb{D}_t$ under the base case scenario, $\bar{R}^t$ is the adapted reputation of the most reputable decision analysts $\mathbb{D}_t$, λ is the specified reduction rate, $\bar{R}^c$ is the adapted reputation of the decision analyst $\mathbb{D}_c$, and R^c is the reputation of the decision analyst $\mathbb{D}_c$ under the base case scenario, with $\bar{R}^c \in [0,1]$ and $\sum_{c=1}^{m} \bar{R}^c = 1.$

Table 7
T2NN aggregated severities and the classification of the barriers

Barriers	T2NN aggregated severities	Class
$\mathbb{B}_1$: Business plan or business strategy	[(0.6718, 0.6197, 0.6334), (0.2239, 0.3126, 0.4033), (0.2045, 0.3073, 0.3122)]	Low severity barrier
$\mathbb{B}_2$: Technology	[(0.6126, 0.5628, 0.5734), (0.2702, 0.3807, 0.4464), (0.2477, 0.3751, 0.3586)]	Low severity barrier
$\mathbb{B}_3$: Funding	[(0.7516, 0.6937, 0.7369), (0.1898, 0.2403, 0.2998), (0.1553, 0.2129, 0.2568)]	Critical severity barrier
$\mathbb{B}_4$: Data managing	[(0.7715, 0.7027, 0.7519), (0.2014, 0.2662, 0.2655), (0.1645, 0.2188, 0.2586)]	Critical severity barrier
$\mathbb{B}_5$: Visibility	[(0.7388, 0.6756, 0.7198), (0.2039, 0.2778, 0.3016), (0.174, 0.2481, 0.2717)]	Medium severity barrier
$\mathbb{B}_6$: Pre-opening requirements	[(0.7726, 0.705, 0.7549), (0.1971, 0.2357, 0.2643), (0.1472, 0.2063, 0.2497)]	Critical severity barrier
$\mathbb{B}_7$: Running and maintaining the platform	[(0.6007, 0.5455, 0.5464), (0.3036, 0.4043, 0.4757), (0.2683, 0.3698, 0.3892)]	Low severity barrier
$\mathbb{B}_8$: Legal aspects	[(0.7006, 0.633, 0.6875), (0.2698, 0.3264, 0.3328), (0.209, 0.2878, 0.3193)]	Medium severity barrier
$\mathbb{B}_9$: Trust	[(0.6796, 0.6033, 0.6544), (0.3008, 0.3548, 0.3457), (0.2281, 0.3096, 0.3438)]	Low severity barrier
$\mathbb{B}_{10}$: Quality of service	[(0.6884, 0.6326, 0.6813), (0.2507, 0.2992, 0.3479), (0.1953, 0.2767, 0.3077)]	Medium severity barrier
$\mathbb{B}_{11}$: Readiness to change	[(0.7202, 0.6622, 0.7114), (0.2232, 0.2694, 0.3184), (0.174, 0.2486, 0.2816)]	Medium severity barrier
$\mathbb{B}_{12}$: Familiarity	[(0.7788, 0.7155, 0.7703), (0.1864, 0.2308, 0.2559), (0.145, 0.1967, 0.2416)]	Critical severity barrier
$\mathbb{B}_{13}$: Value co-creation	[(0.6733, 0.6088, 0.6417), (0.2639, 0.3374, 0.3768), (0.222, 0.3035, 0.3326)]	Low severity barrier

The preliminary results were obtained assuming that the reputation indicators "years of experience" $(\mathbb{I}_1)$, "sharing economy expertise" $(\mathbb{I}_2)$, "sharing economy domain impact" $(\mathbb{I}_3)$, and "qualifications" $(\mathbb{I}_4)$ were equally important. This base case scenario is shown in Figs. 4–5 as "scenario 0". The neutrosophic ERERA-based barrier classification model for the sharing economy produced the reputation vector $R = (0.1205, 0.0952, 0.1319, 0.0767, 0.1196, 0.0894, 0.1018, 0.0679, 0.0767, 0.1205)$. Thus, $\mathbb{D}_3$ was considered as the most reputable decision analyst. One hundred additional scenarios are illustrated in Figure 4. They were simulated using Eqs. (9)–(10) based on the reduction rate $\lambda = 2\%$ of the reputation of the decision analyst $\mathbb{D}_3$ of $R^3 = 0.1319$.

The obtained severity degrees of the barriers under simulated reputation vector scenarios are illustrated in Figure 5. According to Figure 5, the barriers $\mathbb{B}_3$, $\mathbb{B}_6$, and $\mathbb{B}_{12}$ shows high stability to changes in the values of the reputation of the decision analysts. Hence, the sensitivity analysis confirmed that "funding" $(\mathbb{B}_3)$, "pre-opening requirements" $(\mathbb{B}_6)$, and "familiarity" $(\mathbb{B}_{12})$ should be regarded as critical severity barriers for the sharing economy adoption in Serbia. The barriers $\mathbb{B}_4$ and $\mathbb{B}_{11}$ varied between medium and critical severity classes. "Data managing" $(\mathbb{B}_4)$, which was classified as the "critical severity barrier" in the base case scenario, confirmed this class in only 11 out of 100 new scenarios.

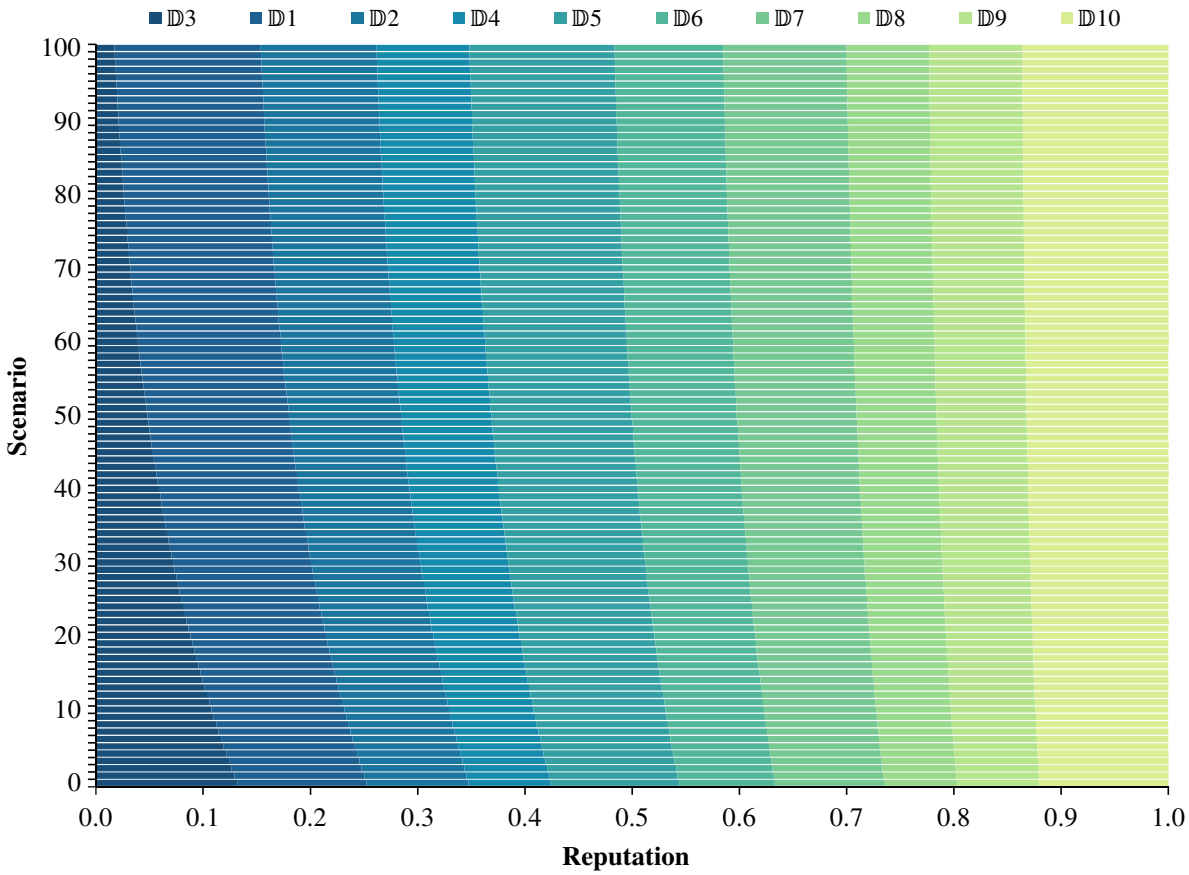

Fig. 4. Simulated reputation vector scenarios.

Most of the additional tests (that is, the scenarios from 44 to 100) showed that the barrier "readiness to change" $(\mathbb{B}_{11})$ could also be considered critical since it attained severity degrees higher than the second classification parameter θ_2. The barriers "legal aspects" $(\mathbb{B}_8)$ and "quality of service" $(\mathbb{B}_{10})$ remained classified as "medium severity barriers" under all additional scenarios. The barriers $\mathbb{B}_5$, $\mathbb{B}_9$, and $\mathbb{B}_{13}$ varied between low and medium severity classes. Medium severity of the barrier "visibility" $(\mathbb{B}_5)$ was confirmed in 62 out of 100 new problem instances, while in others it dropped into the low severity class. However, the barriers "trust" $(\mathbb{B}_9)$ and "value co-creation" $(\mathbb{B}_{13})$ reached severity degrees higher than the first classification parameter $\theta_1 = 0.5$ in the scenarios from 43 to 100 and 34 to 100; that is, they could also be classified as "medium severity barriers". Finally, the initial classification of the barriers "business plan or business strategy" $(\mathbb{B}_1)$, "technology" $(\mathbb{B}_2)$, and "running and maintaining the platform" $(\mathbb{B}_7)$ showed high stability since they remained in the low severity class in 100 novel scenarios.

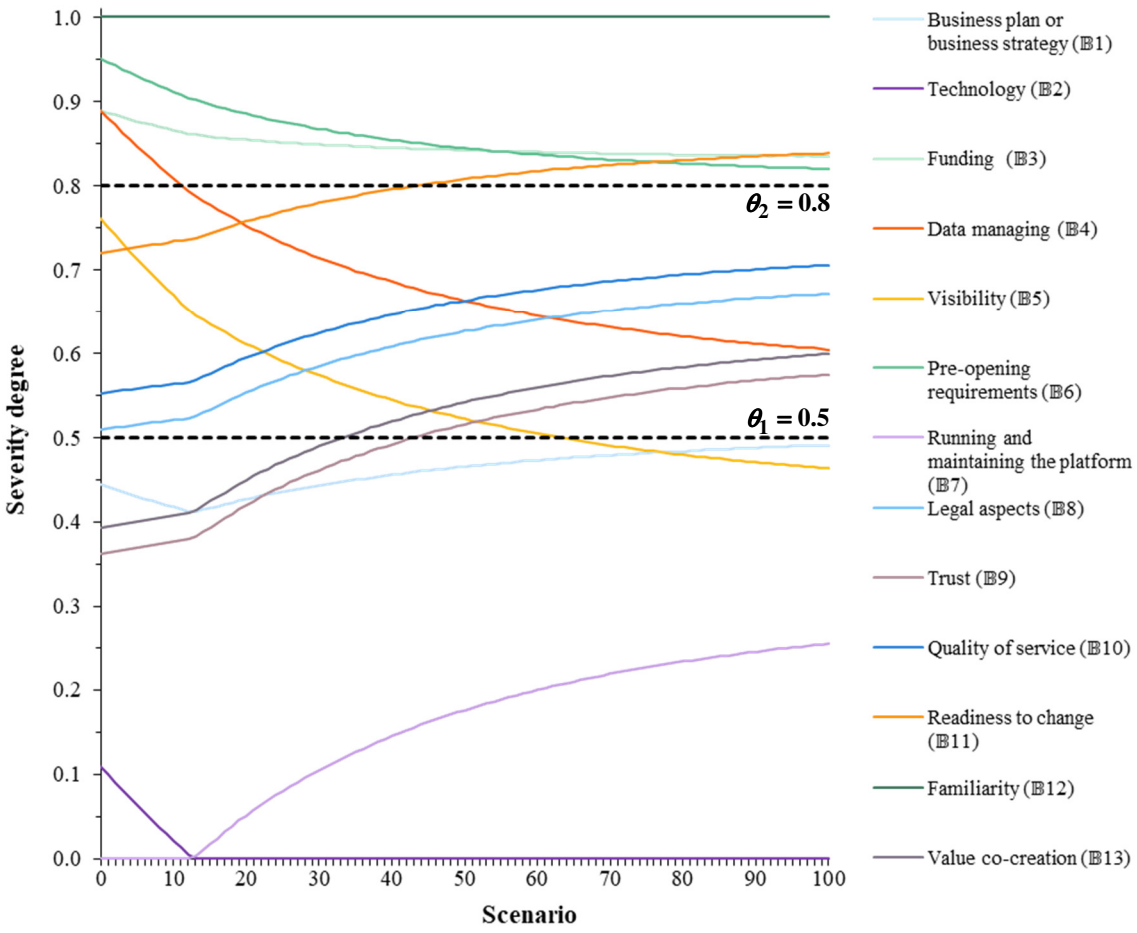

Fig. 5. Sensitivity analysis to changes in the reputation of the decision analysts.

5.3. Implications

The evidence from this research suggests that five critical barriers appear across various scenarios, among which three are related to the category "business infrastructure" and two are from the "power of persistence" category. This indicates that providing resources for starting a business is a more challenging issue than involving people.

As regards the "business infrastructure" category, while funding and various administrative requirements are critical, expert knowledge and technology are not seen as notable sharing economy development obstacles. A low level of trust between peers or in the platform is also not found to be a critical barrier. This result is opposed to the findings of [29], who identified the lack of trust as the most influential barrier, but also much in line with outcomes from [30], where trust was among the least influential barriers.

Noticeable disagreement also exists in the opinions regarding the pre-opening requirements, which partially coincide with capital costs or cost implications [29,30], both referring to the initial investments for implementing SE. Again, while our research as well as study [30] point to the high importance of this issue, study [29] found the opposite. This indicates that the comparison of the results must be taken with caution, bearing in mind not only the diversity of localities but also the specificities of the sharing economy sector.

The obtained evaluation of barriers pinpoints difficulties from real practice [34] faced by the organization in implementing SE. By acknowledging the most critical barriers, policy analysts and all

actors supporting SE, improve their understanding and awareness of problems and may initiate discussion on the most proper means to reduce them.

The classification of barriers derived from expert views provides a basis for considering certain policy and managerial implications. For the specific study area of this research, the following signposts may be pointed out:

i. *When it comes to familiarity, more has to be done to promote the sharing economy and its benefits that will tackle both the problem of familiarity with the concept and awareness of change* – According to recent studies conducted among students in Serbia [35,36], not even the younger population is familiar with the concept of shared mobility. Also, in terms of the percentage of individuals who used any website or app to arrange accommodation from another individual, Serbia (15%) lags the European Union-28 average (21%) [37]. Besides information from marketing channels and peer-to-peer experiences, examples of effective ways to underpin the theoretical and practical skills of sharing economy decision-makers are knowledge hubs and domestic or foreign competence centers. From the perspective of providers and platform operators, different organizations like incubators, accelerators, and startup communities play an important role in getting initial support in the form of knowledge and contacts.
ii. *Pre-opening requirements are related to the numerous factors that need to be satisfied for the startup scaling* – these requirements involve time and cost-consuming activities that use human skills, equipment, and money. Legal documents and regulations for business launching should be reviewed and procedures for their adoption simplified. With the sharing economy in practice, some of these requirements may be easier to meet; for example, paying for the usage of working space instead of owning. Different forms of funding described below are also important for covering or avoiding initial operational costs; that is, the cost of equipment, consulting, etc.
iii. *Investing in the sharing economy businesses is important for their survival, especially in the initial phase of development* – According to [38], startups in Serbia have so far been predominantly financed through their own resources and grants. Besides that, angel investors and venture capital companies can also give financial momentum at a time when sharing economy companies are trying to break into the market. The role of investors is not only to provide finance but also to be the advisor. Besides the aforementioned, adopting adequate public policies and legal regulations that support these innovative concepts and help their development is of great importance. Some of the ways to create favorable conditions for the development and functioning of sharing economy startups are different tax reliefs and innovative forms of funding, as well as better adaptation of regulations and laws to sharing economy business models.

6. Conclusions

This study presented the neutrosophic ERERA-based barrier classification model for the sharing economy. In general, reputation could be measured by various indicators, making it possible to value whether the right person is recognized as a relevant expert and engaged in an MCGDM process. With the help of neutrosophic ERERA, decision analysts can be systematically differentiated based on a desirable spectrum of domain-related reputation indicators. Also, neutrosophic ERERA can produce severity degrees of barriers and categorize them by accounting for the nature of the investigated problem. The number of intrinsic parameters of neutrosophic ERERA equals the number of

reputation indicators plus classification parameters, thus making it very flexible for real-life MCGDM applications.

This real-life case study examined sharing economy perspectives in Serbia. In-depth sensitivity analysis confirmed the stability of the initial barrier classes produced by neutrosophic ERERA. The results showed that all three most critical barriers can be subsumed under initial capital, either in the form of knowledge, equipment, or money. This implies the importance of investing in different resources when launching a sharing economy start-up. Although there is no “one size fits all” solution to overcome barriers, the first instance for sharing economy entrepreneurs should be knowledge hubs and incubators where they can get support in the form of knowledge, money, or both. The findings of our study can serve as valuable insight for all actors in the sharing economy ecosystem who want to learn more about the business conditions while entering the sharing economy scene.

The notable implications of this research can be seen from the practical and methodological side. Regarding the practical ones, this systematic study of barriers can help prospective entrepreneurs understand their business environment, as well as alert on the factors that prevent growth the most, so that mitigation strategies can be developed. Also, this paper can serve as a guide to uncover the most challenging barriers to the sharing economy's initial growth, as well as to determine the severity of the barriers. Besides, the classification of barriers improves understanding and awareness of problems and provides a basis for the discussion among policy analysts and all supporting actors on the most proper environment for the sharing economy. Regarding the methodological merit, the introduced neutrosophic ERERA is intended for all other stakeholders, including policy makers, who should have an adequate perception of barriers that both participants and business actors experience in the sharing economy.

Regarding future research, it is worth noting that the proposed classification model can be extended to other business areas. This applies specifically to those sectors struggling with market penetration, user trust, safety challenges, regulatory complexities, and funding limitations, as is the case with most peer-to-peer (P2P) marketplaces. By customizing barrier categories to fit specific sectors and decision contexts, the model supports informed decision-making. Engaging stakeholders for validation, refinement, and feedback is crucial to ensure the ERERA-based barrier classification model adapts effectively across diverse sectors and decision contexts. Their insights help tailor the model to specific sector challenges, improve accuracy in barrier identification, and prioritize mitigation strategies that align with industry needs. In our future research endeavors, we will apply the formulated neutrosophic ERERA-based barrier classification model to more case studies. Finally, it is suggested for future research to expand the introduced ERERA-based barrier classification model with other fuzzy and neutrosophic sets.

Conflict of Interest

The author declares no conflict of interest.

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Appendix A. Notation

Table A.1
Notations used in the neutrosophic ERERA-based model for barrier classification

Indices and sets	
$l=1,2,\ldots,h$	index of barriers
$c=1,2,\ldots,m$	index of decision analysts
$k=1,2,\ldots,n$	index of reputation indicators
t	auxiliary index
$\mathbb{B}=\{\mathbb{B}_1,\mathbb{B}_2,\ldots,\mathbb{B}_l,\ldots,\mathbb{B}_h\}$	set of barriers
$\mathbb{D}=\{\mathbb{D}_1,\mathbb{D}_2,\ldots,\mathbb{D}_c,\ldots,\mathbb{D}_m\}$	set of decision analysts
$\mathbb{I}=\{\mathbb{I}_1,\mathbb{I}_2,\ldots,\mathbb{I}_k,\ldots,\mathbb{I}_n\}$	set of the reputation indicators
Parameters	
$h\geq 2$	number of barriers
$m\geq 2$	number of decision analysts
$n\geq 2$	number of reputation indicators
$\xi_k\in[0,1]\,(k\in\mathbb{I})$	trade-off parameter of the reputation indicator $\mathbb{I}_k$
$\theta_1\in(0,1)$	the first classification parameter
$\theta_2\in(0,1)$	the second classification parameter
Variables	
$\tilde{Y}_k^c\ (k\in\mathbb{I},c\in\mathbb{D})$	T2NN (self-)appraisal of the reputation under the indicator $\mathbb{I}_k$ given by the decision analyst $\mathbb{D}_c$
$\tilde{A}^c\ (c\in\mathbb{D})$	T2NN aggregated reputation of the decision analyst $\mathbb{D}_c$ under all indicators
$R^c\ (c\in\mathbb{D})$	the reputation of the decision analyst $\mathbb{D}_c$
$\tilde{X}_l^c\ (l\in\mathbb{B},c\in\mathbb{D})$	T2NN severity estimation of the barrier $\mathbb{B}_l$ given by the analyst $\mathbb{D}_c$
$\tilde{Z}_l\ (l\in\mathbb{B})$	T2NN aggregated severity of the barrier $\mathbb{B}_l$ under all analysts
$G_l\ (l\in\mathbb{B})$	severity degree of the barrier $\mathbb{B}_l$

Appendix B

Table B.1
T2NN aggregated reputation matrix

Decision analysts	**Reputation indicators**	
	$\mathbb{I}_1$: Years of experience	$\mathbb{I}_2$: Sharing economy expertise
$\mathbb{D}_1$	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.95,0.9,0.95), (0.1,0.1,0.05), (0.05,0.05,0.1)]
$\mathbb{D}_2$	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]
$\mathbb{D}_3$	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]
$\mathbb{D}_4$	[(0.05,0.1,0.05), (0.8,0.95,0.95), (0.8,0.9,0.8)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]
$\mathbb{D}_5$	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]
$\mathbb{D}_6$	[(0.05,0.1,0.05), (0.8,0.95,0.95), (0.8,0.9,0.8)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]
$\mathbb{D}_7$	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]
$\mathbb{D}_8$	[(0.05,0.1,0.05), (0.8,0.95,0.95), (0.8,0.9,0.8)]	[(0.35,0.3,0.25), (0.6,0.7,0.8), (0.5,0.75,0.65)]
$\mathbb{D}_9$	[(0.05,0.1,0.05), (0.8,0.95,0.95), (0.8,0.9,0.8)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]
$\mathbb{D}_{10}$	[(0.35,0.3,0.25), (0.6,0.7,0.8), (0.5,0.75,0.65)]	[(0.95,0.9,0.95), (0.1,0.1,0.05), (0.05,0.05,0.1)]

Decision analysts	Reputation indicators	
	$\mathbb{I}_3$: Sharing economy domain impact	$\mathbb{I}_4$: Qualifications
$\mathbb{D}_1$	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.35,0.3,0.25), (0.6,0.7,0.8), (0.5,0.75,0.65)]
$\mathbb{D}_2$	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.35,0.3,0.25), (0.6,0.7,0.8), (0.5,0.75,0.65)]
$\mathbb{D}_3$	[(0.95,0.9,0.95), (0.1,0.1,0.05), (0.05,0.05,0.1)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]
$\mathbb{D}_4$	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]
$\mathbb{D}_5$	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]
$\mathbb{D}_6$	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]
$\mathbb{D}_7$	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]
$\mathbb{D}_8$	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]
$\mathbb{D}_9$	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]
$\mathbb{D}_{10}$	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]

Table B.2

Decision analysts' linguistic severity estimation of the barriers.

Barriers	Decision analysts									
	$\mathbb{D}_1$	$\mathbb{D}_2$	$\mathbb{D}_3$	$\mathbb{D}_4$	$\mathbb{D}_5$	$\mathbb{D}_6$	$\mathbb{D}_7$	$\mathbb{D}_8$	$\mathbb{D}_9$	$\mathbb{D}_{10}$
$\mathbb{B}_1$: Business plan or business strategy	VHS	HS	MHS	HS	MHS	HS	HS	VHS	LS	MHS
$\mathbb{B}_2$: Technology	MHS	MS	VHS	HS	VLS	MHS	HS	MLS	HS	MHS
$\mathbb{B}_3$: Funding	MS	VHS	HS	EHS	HS	VHS	VHS	MS	VHS	HS
$\mathbb{B}_4$: Data managing	HS	EHS	EHS	VHS	HS	MHS	HS	MHS	LS	MS
$\mathbb{B}_5$: Visibility	MHS	HS	EHS	VHS	MHS	VHS	HS	MS	HS	MS
$\mathbb{B}_6$: Pre-opening requirements	MLS	MHS	VHS	EHS	HS	HS	VHS	MLS	EHS	VHS
$\mathbb{B}_7$: Running and maintaining the platform	MLS	MLS	VLS	HS	HS	HS	VHS	HS	LS	HS
$\mathbb{B}_8$: Legal aspects	MS	LS	VLS	EHS	MS	EHS	VHS	LS	HS	VHS
$\mathbb{B}_9$: Trust	MLS	MLS	ELS	EHS	MLS	VHS	HS	VLS	EHS	VHS
$\mathbb{B}_{10}$: Quality of service	MS	VHS	VLS	EHS	VHS	VHS	VHS	HS	VLS	MS
$\mathbb{B}_{11}$: Readiness to change	MS	VHS	VLS	MS	VHS	EHS	HS	MHS	VHS	VHS
$\mathbb{B}_{12}$: Familiarity	MS	VHS	MS	EHS	VHS	EHS	HS	HS	HS	VHS
$\mathbb{B}_{13}$: Value co-creation	MLS	MHS	ELS	EHS	VHS	HS	HS	VHS	MLS	HS

Table B.3

T2NN barrier severity matrix.

Decision analysts	Barriers					
	$\mathbb{B}_1$: Business plan or business strategy	$\mathbb{B}_2$: Technology	$\mathbb{B}_3$: Funding	$\mathbb{B}_4$: Data managing	...	$\mathbb{B}_{13}$: Value co-creation
$\mathbb{D}_1$	[(0.8,0.75,0.8), (0.15,0.15,0.25), (0.1,0.15,0.2)]	[(0.6,0.55,0.55), (0.25,0.4,0.45), (0.25,0.45,0.35)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	⋯	[(0.45,0.35,0.35), (0.5,0.65,0.55), (0.4,0.65,0.55)]
$\mathbb{D}_2$	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.8,0.75,0.8), (0.15,0.15,0.25), (0.1,0.15,0.2)]	[(0.95,0.9,0.95), (0.1,0.1,0.05), (0.05,0.05,0.1)]	⋯	[(0.6,0.55,0.55), (0.25,0.4,0.45), (0.25,0.45,0.35)]
$\mathbb{D}_3$	[(0.6,0.55,0.55), (0.25,0.4,0.45), (0.25,0.45,0.35)]	[(0.8,0.75,0.8), (0.15,0.15,0.25), (0.1,0.15,0.2)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	[(0.95,0.9,0.95), (0.1,0.1,0.05), (0.05,0.05,0.1)]	⋯	[(0.05,0.1,0.05), (0.8,0.95,0.95), (0.8,0.9,0.8)]
$\mathbb{D}_4$	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	[(0.95,0.9,0.95), (0.1,0.1,0.05), (0.05,0.05,0.1)]	[(0.8,0.75,0.8), (0.15,0.15,0.25), (0.1,0.15,0.2)]	⋯	[(0.95,0.9,0.95), (0.1,0.1,0.05), (0.05,0.05,0.1)]
$\mathbb{D}_5$	[(0.6,0.55,0.55), (0.25,0.4,0.45), (0.25,0.45,0.35)]	[(0.15,0.2,0.1), (0.7,0.85,0.85), (0.6,0.8,0.7)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	⋯	[(0.8,0.75,0.8), (0.15,0.15,0.25), (0.1,0.15,0.2)]

Decision analysts	Barriers					
	$\mathbb{B}_1$: Business plan or business strategy	$\mathbb{B}_2$: Technology	$\mathbb{B}_3$: Funding	$\mathbb{B}_4$: Data managing	...	$\mathbb{B}_{13}$: Value co-creation
$\mathbb{D}_6$	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	[(0.6,0.55,0.55), (0.25,0.4,0.45), (0.25,0.45,0.35)]	[(0.8,0.75,0.8), (0.15,0.15,0.25), (0.1,0.15,0.2)]	[(0.6,0.55,0.55), (0.25,0.4,0.45), (0.25,0.45,0.35)]	⋯	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]
$\mathbb{D}_7$	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	[(0.8,0.75,0.8), (0.15,0.15,0.25), (0.1,0.15,0.2)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	⋯	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]
$\mathbb{D}_8$	[(0.8,0.75,0.8), (0.15,0.15,0.25), (0.1,0.15,0.2)]	[(0.45,0.35,0.35), (0.5,0.65,0.55), (0.4,0.65,0.55)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	[(0.6,0.55,0.55), (0.25,0.4,0.45), (0.25,0.45,0.35)]	⋯	[(0.8,0.75,0.8), (0.15,0.15,0.25), (0.1,0.15,0.2)]
$\mathbb{D}_9$	[(0.35,0.3,0.25), (0.6,0.7,0.8), (0.5,0.75,0.65)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	[(0.8,0.75,0.8), (0.15,0.15,0.25), (0.1,0.15,0.2)]	[(0.35,0.3,0.25), (0.6,0.7,0.8), (0.5,0.75,0.65)]	⋯	[(0.45,0.35,0.35), (0.5,0.65,0.55), (0.4,0.65,0.55)]
$\mathbb{D}_{10}$	[(0.6,0.55,0.55), (0.25,0.4,0.45), (0.25,0.45, 0.35)]	[(0.6,0.55,0.55), (0.25,0.4,0.45), (0.25,0.45,0.35)]	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]	[(0.5,0.45,0.5), (0.35,0.55,0.5), (0.35,0.55,0.45)]	⋯	[(0.7,0.65,0.65), (0.2,0.3,0.4), (0.2,0.25,0.3)]

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