STRATEGIC BUSINESS MANAGEMENT: PLANNING AND FORECASTING

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FUZZY EVALUATION OF THE COMPETITIVENESS OF BUSINESS MODELS OF ENTERPRISES

Summary

The study analyzes the factors that are determinants of competitiveness of business models of enterprises. The methodological approach to the comparative assessment of the competitiveness of business models of enterprises using the tools of fuzzy sets theory and fuzzy logic, which allows to take into account the fuzzy information received from specialists and experts, is developed. CANVAS business model criteria are considered as evaluation criteria. Two calculation schemes for analyzing the competitiveness of business models of enterprises have been implemented. The first was implemented using fuzzy multi-criteria evaluation methods, in particular, the Fuzzy TOPSIS method. The second scheme is based on Mamdani's fuzzy inference algorithm. The fuzzy Delphi method is proposed to ensure the consistency of expert evaluations. The methodological approach is practically implemented as a framework in the Matlab computing system. The developed methodological approach can be useful in competitive analysis and strategic planning of the enterprise.

Introduction

The modern paradigm of strategic management should be based on tools that take into account the complexity of the market environment, instability, uncertainty and unpredictable nature of the influence of external environment factors. The use of classical models in strategic analysis, formation of the mission and strategic goals, development of strategic alternatives, strategic choice and strategic control involves the introduction of determinism in situations that are characterized by imprecision, "fuzzy" and indistinctness of certain estimates and parameters, which, in turn, can cause serious strategic errors, miscalculations and failures [1]. This especially applies to the issues of

competitive analysis of enterprises and, in particular, to the problem of assessing their competitiveness [2]. Consequently, changes in the nature of competition, the need to adapt to a turbulent and dynamic external environment, increased competition, especially in a pandemic environment, necessitate the development and application of new scientific approaches to the measurement and evaluation of enterprise competitiveness, which would allow the process of comparative analysis to consider relevant information, subjective, informal, fuzzy contributions, ideas and expert opinions. Accordingly, the most promising direction of modern applied research in strategic management is the use of logical-linguistic models and methods of fuzzy sets theory [18], which are highly adaptable to expert data, to qualitative, verbal description of analyzed parameters, and are flexible enough and respond adequately to input information [1]. The main provisions of the theory of fuzzy logic, based on the mathematical theory of fuzzy sets, were proposed by the American mathematician Lotfi Zadeh [18]. An important step in the development of "fuzzy" methodology was the fuzzy approximation theorem [12] proved in 1993 by Bart Kosko, a professor at the University of Southern California. According to it, any mathematical system can be approximated by a system built on fuzzy logic. Kosko's work gave a powerful impetus for further research in this area, and practical achievements in the field of fuzzy logic were theoretically justified. At present, the fuzzy sets approach, in fact, is an alternative to the generally accepted quantitative deterministic methods of systems analysis and is widely used in strategic management and, in particular, in competitive analysis [2; 7; 10]; in [2] developed a methodological approach to the comparative assessment of the competitiveness of enterprises using tools of fuzzy multi-criteria analysis based on the superposition of COPRAS-G and Fuzzy COPRAS methods, where fuzzy values of evaluation criteria weights as well as their partial indicators are calculated using Fuzzy AHP method; in [7] proposed a method for assessing the competitiveness of an enterprise using fuzzy logic, based on the construction of a multilevel hierarchical model in the form of a neuro-fuzzy network; in [10] the authors also use the mathematical apparatus of fuzzy logic for the same purpose.

The purpose of this study is to develop a methodological toolkit for the comparative assessment of the competitiveness of business models of enterprises as part of their strategic competitiveness using the tools of fuzzy methodology. To achieve this goal and solve the tasks of assessing the level of competitiveness of business models it is supposed to use the tools of fuzzy sets theory, in particular, the methods of fuzzy multi-criteria analysis (Fuzzy TOPSIS method [11]) and fuzzy inference systems [14]. Note that a fuzzy inference process is a defined procedure or algorithm for obtaining fuzzy inferences based on fuzzy conditions using the concepts of fuzzy logic. This process integrates all the basic concepts of fuzzy set theory: membership functions, linguistic variables, fuzzy logic operations, fuzzy implication and fuzzy composition methods.

Part 1. The business model of the enterprise and its competitiveness

People now live in an era of short-term competitive advantage, due to the increasing speed of technological change and its proliferation, the era of information (digital) technology and the increasing intensity of knowledge. Therefore, these competitive advantages can only be maintained and strengthened by constantly reviewing and analyzing their root causes and principles of creation, especially in the context of the achievements of competing companies.

The basis of competitive advantages of an enterprise, its strategic competitiveness is a successful competitive business model. Application of enterprise business model concept is necessary to achieve long-term strategic, operational and tactical goals, namely:

– evaluation and analysis of business efficiency of the enterprise in comparison with other similar enterprises;
– optimization of enterprise business processes;
– assessment of the potential and investment attractiveness of business today and in the future;
– optimizing financial flows and maximizing the level of value that the company creates for consumers and its business stakeholders.

According to Osterwalder and Pigneur [15], a business model is what distinguishes an enterprise from others, its uniqueness, which is expressed through the relationship between the most critical success factors of the enterprise. The authors believe that the business model is more important than the mission, strategy, cash flow plan. To be useful, the structure of a business model must be sufficiently simple, logical, measurable, comprehensive and functionally relevant [15]. A broader and more complete definition of this term is presented in [5], where the business model of the enterprise is a set of elements that characterize the fundamental logic of its functioning, different from competitors, based on the use of key competencies for the most effective allocation of strategic resources in the system of business processes to create a product (service) that meets the priorities of consumers. The competitive business model of an enterprise must be adaptive, dynamic and capable of development. Its success depends on many factors in the micro- and macro-environment and interaction with the business models of competing companies. Competitive business model allows to form a solid basis for business restructuring in order to open new opportunities for its development and provides a high level of resistance to the negative influences of the external environment [3].

An important aspect that determines the competitiveness of a business model is its innovativeness, which predetermines its ability to meet an unsatisfied group of consumers or unmet consumer needs, to provide new or different benefits from the use of products and services or to deliver value to consumers in new and unconventional ways [16].

The authors [13] consider the formation of sustainable "competitive advantages" of the business model of the enterprise in a dynamic environment through the prism of two main approaches:

– temporary approach – firms and organizations need to continually update product and network management information to meet the volatile and fluid demands of the marketplace. According to this approach, the emphasis is on the ability of business models to fundamentally shape the structure and processes of firms and organizations toward unique features that should support their competitive advantage over their competitors;

– sustainable approach – once market needs are met, firms and organizations need to develop and implement actions that will allow them to maintain a valuable competitive position. The implication of this is that they must focus on how to continuously gain long-term value through the uniqueness of their business, the irreplaceability of their business models, and their ability to effectively substitute resources.

The authors conclude that sustainable growth and success in business depends not only on great ideas and intuition of the leader, but also on the ability to create and constantly improve the business model [13].

In the work of Henry Chesbrough [9] a list of criteria (requirements for the business model) that determine its competitiveness was formulated:

1) value proposition formation (the value created for users by the proposition based on the technology);

2) defining the market segment (determining the users for whom the technology is useful and the purposes for which it will be used);

3) determining the structure of the firm's value chain necessary to create and distribute the offering, identifying the additional assets necessary to maintain the firm's position in this chain;

4) clarification of the mechanism of income generation for the enterprise and assessment of the cost structure, as well as the target gross profit when using the proposal, taking into account the selected options for the value proposition and the structure of the value chain;

5) a description of the company's position in the value creation network linking suppliers and customers, in particular the identification of potential partners and competitors;

6) formulating a competitive strategy by which the innovative enterprise will gain and maintain an advantage over its competitors.

According to M. Johnson, C. Christensen and H. Kagermann [4], the competitiveness of an enterprise business model is determined by:

1) key resources (people, technology, products, equipment, information, supply channels, partnerships, alliances, etc.);

2) key processes (system of indicators, company rules, norms);

3) value proposition for customers (key customer; need that can be met; company's offer);

4) profit formula (income generation model, cost structure, marginal profit model, rate of turnover of resources).

In [8] it is argued that the structural elements of the business model of the enterprise, which can be used as criteria for its analysis and evaluation of competitiveness, are:

– customer interaction (fulfillment and support, information and understanding, relationships and pricing);

– the main strategy (the mission of the business, the scope of the product/market, the basis for differentiation);

– strategic resources (core skills, strategic assets, core processes);

– network of values (suppliers, partners, customers).

The paper [6] argues that the growth of company value, strengthening its competitiveness is based not so much on technological innovation, as on an innovative business model, determined by the following elements: consumer choice, unique value proposition, profit model, strategic control and scale of operations.

The most complete and meaningful of the already used methods of strategic management, allowing to analyze the business model, in terms of its efficiency and opportunities for development, is the Business Model CANVAS (Figure 1), developed by Osterwalder and Pigneur [15] on the basis of research and generalization of more than ten universal business models of other authors.

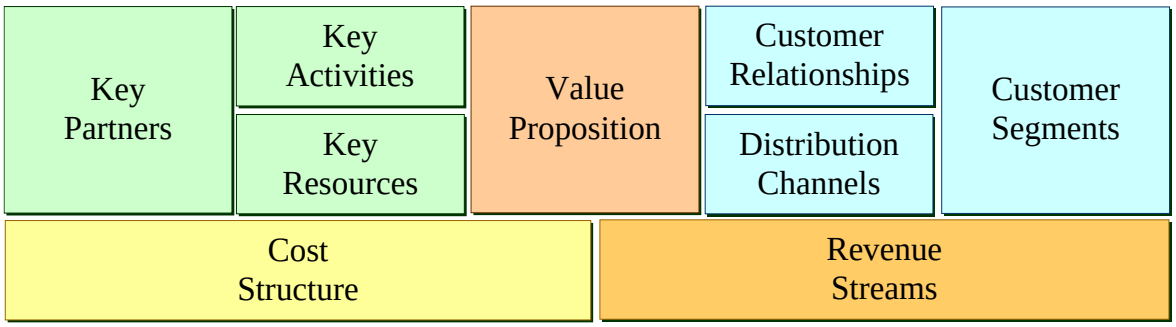

Figure 1. Structure of the CANVAS business model (BMC)

Source: [15]

The Osterwalder and Pigneur BMC consists of nine blocks:

– the three blocks on the left side of the Canvas are related to internal processes and efficiency: key resources (the most important assets needed to run the business model), key activities (describe the types of work that the company can or should be able to perform at a high level at all stages of its activities) and key partners (the network of suppliers and partners with whom the company cooperates and without whom it cannot function). Partnerships can be strategic alliances between non-competitors as well as competitors (coopetition), joint ventures to develop new business, or buyer-supplier relationships);

– the three blocks on the right side of the Canvas are related to customers and value: customer segments (the different groups of people or organizations that the company seeks to reach and serve, for whom value, products and services are created), channels (describes how the company communicates and reaches customer segments) and customer relationships (defines the type or nature of the relationships that the company establishes with target customer segments and how it organizes and supports them);

– the value proposition is at the center (describes a set of products and services that create value for a particular customer segment; may include characteristics such as novelty, performance, personalization, performance, design, brand/status, price, cost reduction, risk reduction, affordability and convenience/utility);

– cost structure (describes all the costs the company incurs to operate the business model) and the revenue streams (represents the revenue structure the company receives from each segment) are presented at the bottom of the Canvas.

Part 2. Comparative evaluation of business models of enterprises

Assessing the competitiveness of the business model of the enterprise is a complex task, which is based on a comparative analysis with other competitors and is characterized by phenomenological features, namely the informal nature of the assessment procedures, the need for multi-criteria analysis, the ambiguity of expert evaluations. Other equally important problems in this process are cognitive barriers arising from language differences, peculiarities of individual expert preference systems, and differences in their professional experience [2].

The developed methodological approach based on the use of fuzzy multi-criteria analysis and fuzzy logic (Figure 2) is offered to take into account subjective, unformalized, fuzzy input data, opinions and judgments of experts.

Consider in more detail the main steps of this approach.

At **the first stage** it is supposed to form an expert group (K experts) of specialists possessing corresponding competences in the subject area. It is advisable to include both strategic analysts of the enterprise and external consultants-practitioners with experience in analytical work and knowledge of the specifics, the logical and causal links of the industry.

Stage 2. The identification of direct competition enterprises can be carried out with the help of strategic competitor group maps, cluster analysis, discriminant analysis or the use of Kohonen maps.

Stage 3. This study uses the CANVAS business model criteria as criteria for assessing the competitiveness of competing business models [15] (Figure 3).

Stage 4. To determine the fuzzy values of the weight coefficients of the evaluation criteria you need to perform the following steps:

1. Assessment by experts of the importance of the CANVAS criteria (BMC criteria) using linguistic evaluations based on a set of terms: T={Extremely Low (EL), Very Low (VL); Low (L); Medium (M); High (H); Very High (VH),

Extremely High (EH)}. The semantics of the terms are defined by fuzzy triangular numbers in the interval [0; 6] with the corresponding membership functions (Fig. 4). So, EL: (0; 0; 1); VL: (0; 1; 2); L: (1; 2; 3); M: (2; 3; 4); H: (3; 4; 5); VH: (4; 5; 6); EH: (5; 6; 6). The result of this stage is a linguistic evaluation: L_{KP}^{k}, L_{KA}^{k}, L_{VP}^{k}, L_{CR}^{k}, L_{CSg}^{k}, L_{KR}^{k}, L_{DC}^{k}, L_{CSt}^{k}, L_{RS}^{k}, $k = \overline{1, K}$.

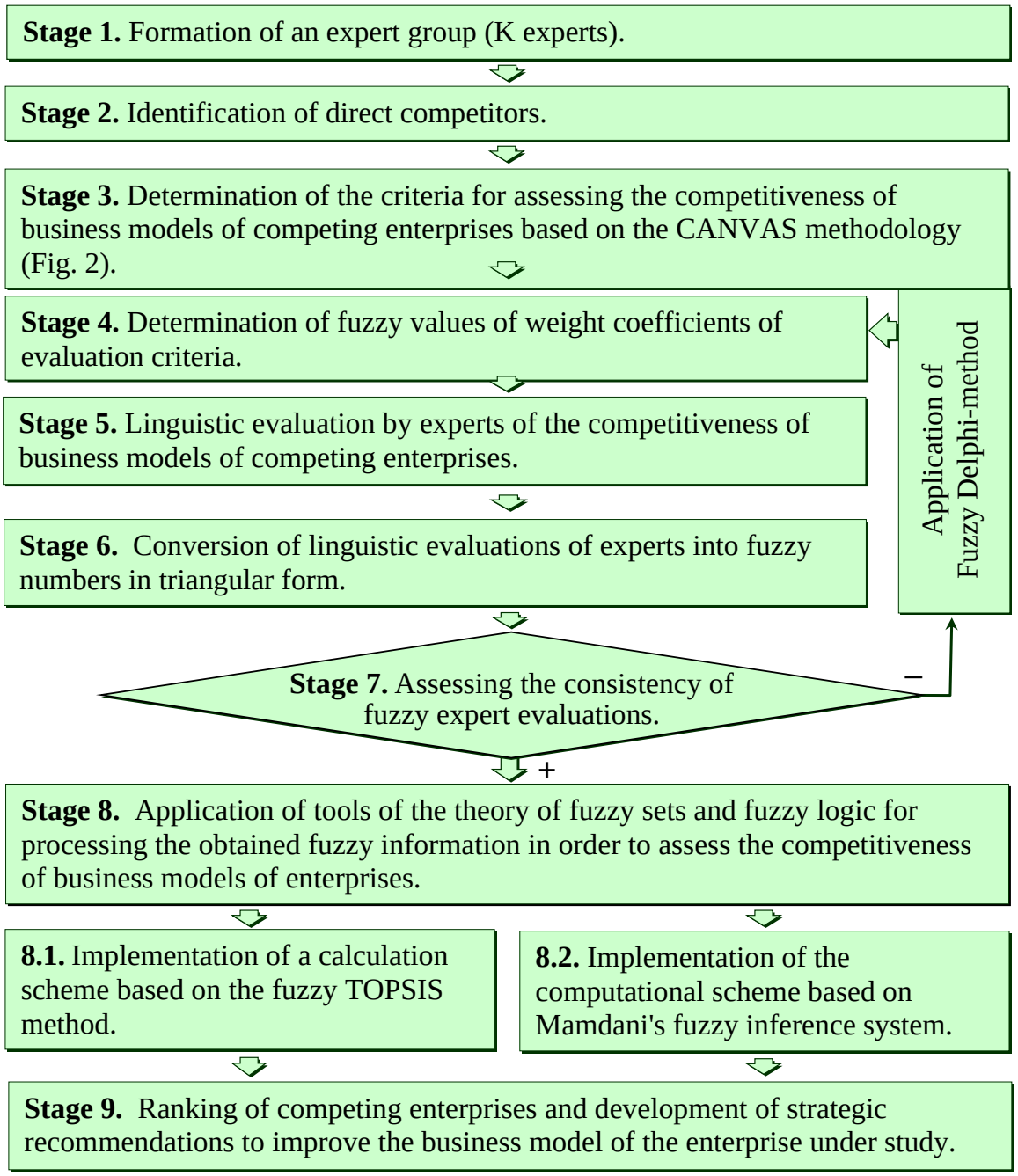

Figure 2. Stages of application of methodical approach to comparative evaluation of competitiveness of business models of competing enterprises

Source: developed by the author

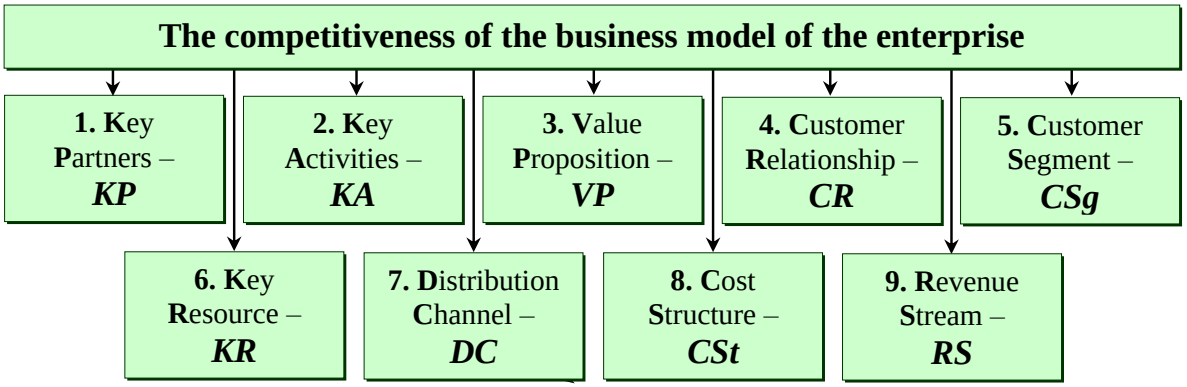

Figure 3. Criteria for assessing the competitiveness of business models of enterprises according to the CANVAS methodology

Source: [15]

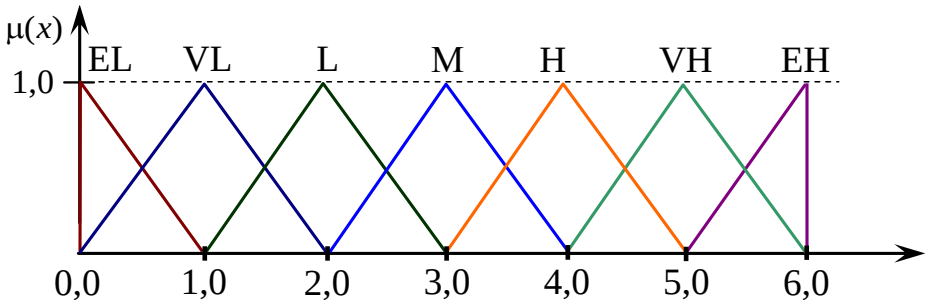

Figure 4. Triangular membership functions of evaluation terms

Source: [18]

Note that the analytical representation of the membership function, for example, for a term with a triangular representation $\tilde{u} = (a; b; c)$ will be as follows (1):

$$\mu(x) = \begin{cases} 0, \ x < a; \\ (x-a)/(b-a), \ x \in [a; b]; \\ (c - x/(c-b), \ x \in [b; c]; \\ 0, \ x > c. \end{cases} \quad (1)$$

2. Conversion of linguistic evaluations of the importance of BMC criteria into fuzzy triangular numbers:

$$L_{KP}^k \to \tilde{w}_{KP}^k, \ L_{KA}^k \to \tilde{w}_{KA}^k, \ L_{VP}^k \to \tilde{w}_{VP}^k, \ L_{CR}^k \to \tilde{w}_{CR}^k, \ L_{CSg}^k \to \tilde{w}_{CSg}^k,$$
$$L_{KR}^k \to \tilde{w}_{KR}^k, \ L_{DC}^k \to \tilde{w}_{DC}^k, \ L_{CSt}^k \to \tilde{w}_{CSt}^k, \ L_{RS}^k \to \tilde{w}_{RS}^k.$$

3. Aggregation of fuzzy expert evaluations using formulas:

$$\frac{1}{K} \bigoplus_{k=1}^{K} \tilde{w}_{KP}^k = \tilde{w}_{KP} = \tilde{w}_1, \ \frac{1}{K} \bigoplus_{k=1}^{K} \tilde{w}_{KA}^k = \tilde{w}_{KA} = \tilde{w}_2, \ \frac{1}{K} \bigoplus_{k=1}^{K} \tilde{w}_{VP}^k = \tilde{w}_{VP} = \tilde{w}_3,$$

$$\frac{1}{K}\bigoplus_{k=1}^{K}\tilde{w}_{CR}^{k}=\tilde{w}_{CR}=\tilde{w}_4,\ \frac{1}{K}\bigoplus_{k=1}^{K}\tilde{w}_{CSg}^{k}=\tilde{w}_{CSg}=\tilde{w}_5,\ \frac{1}{K}\bigoplus_{k=1}^{K}\tilde{w}_{KR}^{k}=\tilde{w}_{KR}=\tilde{w}_6,$$
$$\frac{1}{K}\bigoplus_{k=1}^{K}\tilde{w}_{DC}^{k}=\tilde{w}_{DC}=\tilde{w}_7,\ \frac{1}{K}\bigoplus_{k=1}^{K}\tilde{w}_{CSt}^{k}=\tilde{w}_{CSt}=\tilde{w}_8,\ \frac{1}{K}\bigoplus_{k=1}^{K}\tilde{w}_{RS}^{k}=\tilde{w}_{RS}=\tilde{w}_9.$$

At **stage 5**, the experts perform a linguistic evaluation of the competitiveness of competing business models using the above set of T competing enterprises ($i=\overline{1,n}$) for each BMC criterion:

$$L^k=\left\|l_{ij}^k\right\|_{n\times 9}=\begin{pmatrix} l_{11}^k & l_{12}^k & \ldots & l_{19}^k \\ l_{21}^k & l_{21}^k & \ldots & l_{29}^k \\ \ldots & \ldots & \ldots & \ldots \\ l_{n1}^k & l_{n2}^k & \ldots & l_{n9}^k \end{pmatrix}$$

At **stage 6**, it is necessary to convert these linguistic estimates into fuzzy numbers in triangular form with appropriate membership functions:

$$L^k=\left\|l_{ij}^k\right\|_{n\times 9}\longrightarrow\ \tilde{X}^k=\begin{pmatrix} \tilde{x}_{11}^k & \tilde{x}_{12}^k & \ldots & \tilde{x}_{19}^k \\ \tilde{x}_{21}^k & \tilde{x}_{21}^k & \ldots & \tilde{x}_{29}^k \\ \ldots & \ldots & \ldots & \ldots \\ \tilde{x}_{n1}^k & \tilde{x}_{n2}^k & \ldots & \tilde{x}_{n9}^k \end{pmatrix}=$$

$$=\begin{pmatrix} (a_{11}^k;\,b_{11}^k;\,c_{11}^k) & (a_{12}^k;\,b_{12}^k;\,c_{12}^k) & \ldots & (a_{19}^k;\,b_{19}^k;\,c_{19}^k) \\ (a_{21}^k;\,b_{21}^k;\,c_{21}^k) & (a_{22}^k;\,b_{22}^k;\,c_{22}^k) & \ldots & (a_{29}^k;\,b_{29}^k;\,c_{29}^k) \\ \ldots & \ldots & \ldots & \ldots \\ (a_{n1}^k;\,b_{n1}^k;\,c_{n1}^k) & (a_{n2}^k;\,b_{n2}^k;\,c_{n2}^k) & \ldots & (a_{n9}^k;\,b_{n9}^k;\,c_{n9}^k) \end{pmatrix},\ \text{that is}$$

$$L^k=\left\|l_{ij}^k\right\|_{n\times 9}\longrightarrow\ \tilde{X}^k=\left\|\tilde{x}_{ij}^k\right\|_{n\times 9},\ \text{where}\ \tilde{x}_{ij}^k=(a_{ij}^k;\,b_{ij}^k;\,c_{ij}^k).$$

It should be noted that for the formation of strategic recommendations to improve the business model of the enterprise can be useful visual geometric interpretation of fuzzy evaluations of the studied (*i*-th) and "ideal" (*) enterprises in the form of fuzzy CANVAS-enneagon (Figure 5), which allows to conclude on the directions of improvement depending on the gaps between these enterprises for each criterion. The corresponding coordinates are calculated by the formulas:

$$\tilde{x}_{ij}=\frac{1}{K}\bigoplus_{k=1}^{K}\tilde{x}_{ij}^k=\left(\frac{1}{K}\sum_{k=1}^{K}a_{ij}^k;\ \frac{1}{K}\sum_{k=1}^{K}b_{ij}^k;\ \frac{1}{K}\sum_{k=1}^{K}c_{ij}^k\right)=(a_{ij};\,b_{ij};\,c_{ij}),\qquad(2)$$

$$\tilde{x}_j^*=\frac{1}{K}\bigoplus_{k=1}^{K}\max_i(\tilde{x}_{ij}^k)=\left(\frac{1}{K}\sum_{k=1}^{K}\max_i(a_{ij}^k);\frac{1}{K}\sum_{k=1}^{K}\max_i(b_{ij}^k);\ \frac{1}{K}\sum_{k=1}^{K}\max_i(c_{ij}^k)\right)=(a_j^*;b_j^*;c_j^*).\qquad(3)$$

To assess the consistency of experts' fuzzy evaluations of the importance of the CPA criteria and competing enterprises on these criteria at **stage 7**, it is necessary to calculate appropriate concordance coefficients, and in case of significant discrepancies in experts' evaluations, the Fuzzy Delphi method can be used.

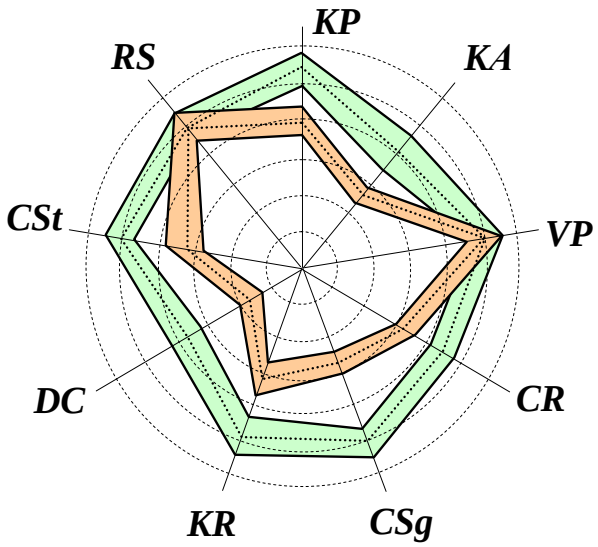

Figure 5. Fuzzy CANVAS-enneagons of "ideal" and investigated enterprises

Source: developed by the author

In the case of a satisfactory agreement of expert evaluations, it is possible to move on to **stage 8**, and two calculation schemes are proposed to assess the competitiveness of business models of enterprises:

Scheme 1 (based on fuzzy multi-criteria analysis using the fuzzy TOPSIS method [11]) contains the following steps:

1. Normalization of the obtained values by the formula:

$$\tilde{u}_{ij} = \left(\frac{a_{ij}}{r_j^+}; \frac{b_{ij}}{r_j^+}; \frac{c_{ij}}{r_j^+} \right), \text{ where } r_j^+ = \max_i c_{ij}, \ (\ i = \overline{1,n};\ j = \overline{1,9}\ ).$$

2. "Weighing" the normalized matrix using the ratio:

$$\tilde{v}_{ij} = \tilde{w}_j \otimes \tilde{u}_{ij} = (w_j^{\alpha};\ w_j^{\beta};\ w_j^{\gamma}) \otimes$$

$$\otimes (a_{ij};\ b_{ij};\ c_{ij}) = (w_j^{\alpha} a_{ij};\ w_j^{\beta} b_{ij};\ w_j^{\gamma} c_{ij}) = (\alpha_{ij};\ \beta_{ij};\ \gamma_{ij}).$$

3. Determination of fuzzy values of "ideal positive solution" (FIPS) $\tilde{A}^+$ and "ideal negative solution" (FINS) $\tilde{A}^-$.

Let $\phi_j^+ = \max_i \gamma_{ij}$ and $\phi_j^- = \min_i \alpha_{ij}$, then $\tilde{A}^+ = (\tilde{v}_1^+; \tilde{v}_2^+; ...; \tilde{v}_9^+)$, where $\tilde{v}_j^+ = (\phi_j^+; \phi_j^+; \phi_j^+)$; $\tilde{A}^- = (\tilde{v}_1^-; \tilde{v}_2^-; ...; \tilde{v}_9^-)$, where $\tilde{v}_j^- = (\phi_j^-; \phi_j^-; \phi_j^-)$.

4. Calculation of the "distances" between each of the given alternatives (competing enterprises) and

a) fuzzy "ideal positive solution":

$$d(\tilde{A}_i;\ \tilde{A}^+) = \sum_{j=1}^{9} d(\tilde{v}_{ij};\tilde{v}_j^+) = \sum_{j=1}^{9} \sqrt{\frac{1}{3}((\alpha_{ij} - \phi_j^+)^2 + (\beta_{ij} - \phi_j^+)^2 + (\gamma_{ij} - \phi_j^+)^2)};$$

б) fuzzy "ideal negative solution":

$$d(\tilde{A}_i;\ \tilde{A}^-) = \sum_{j=1}^{9} d(\tilde{v}_{ij};\tilde{v}_j^-) = \sum_{j=1}^{9} \sqrt{\frac{1}{3}((\alpha_{ij} - \phi_j^-)^2 + (\beta_{ij} - \phi_j^-)^2 + (\gamma_{ij} - \phi_j^-)^2)}.$$

5. Calculation of the relative distance from each of the given alternatives to FIPS and FINS using the formula: $CA_i = \dfrac{d(\tilde{A}_i;\ \tilde{A}^-)}{d(\tilde{A}_i;\ \tilde{A}^-) + d(\tilde{A}_i;\ \tilde{A}^+)}$.

The obtained values CA_i $(i = \overline{1,n})$ allows to conclude about the prevalence and competitiveness of business models of enterprises.

Scheme 2 is based on the use of logical-linguistic modelling tools based on Mamdani's fuzzy inference algorithm [14] and contains the following steps:

1. Formation of a fuzzy knowledge base (FKB) to assess the competitiveness of business models of competing enterprises. This procedure is the most responsible and time-consuming, since it contains a list of fuzzy rules formed on the basis of the experience and knowledge of experts (Table 1).

2. Application of Mamdani's fuzzy inference algorithm (Figure 6).

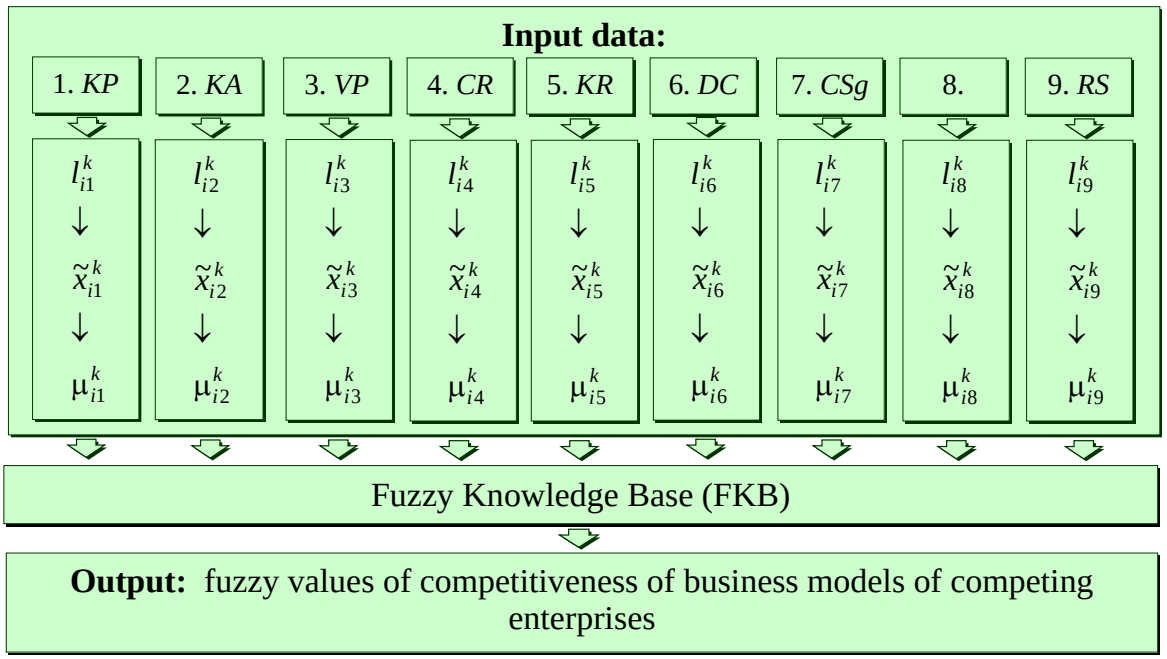

Figure 6. Application of Mamdani's fuzzy inference algorithm

Source: developed by the author

Fuzzy rules for logical inference according to the Mamdani algorithm [14] can be written using logical operations. For example, the rules r_{11}, r_{12}, …, r_{1N_1} are interpreted as follows:

if $l_{i1}^k = EL$ and $l_{i2}^k = EL$ and … and $l_{i9}^k = EL$ with ν_{11} or

if $l_{i1}^k = VL$ and $l_{i2}^k = EL$ and … and $l_{i9}^k = EL$ with ν_{12} or

… … … … …

if $l_{i1}^k = EL$ and $l_{i2}^k = EL$ and … and $l_{i9}^k = VL$ with ν_{1N_1} then $CA_i^k = EL$.

As follows from Figure 6, this scheme is used for the linguistic evaluations of each *k*-th expert ($k = \overline{1, K}$) for each enterprise, with each rule in accordance with Table 1 applied with a certain weighting coefficient, which is determined expertly based on the importance of the BMC criteria for assessing the competitiveness of business models.

Table 1

Fuzzy Knowledge Base (FKB) for determining the level of competitiveness of business models of enterprises

Rule No.	**Linguistic values of input variables**				**Weighting factors**	**The value of the original variable**
	l_{i1}^k	l_{i2}^k	…	l_{i9}^k		
r_{11}	*EL*	*EL*	…	*EL*	ν_{11}	$CA_i^k = EL$
r_{12}	*VL*	*EL*	…	*EL*	ν_{12}	
…	…	…	…	…	…	
r_{1N_1}	*EL*	*EL*	…	*VL*	ν_{1N_1}	
r_{21}	*VL*	*VL*	…	*VL*	ν_{21}	$CA_i^k = VL$
r_{22}	*EL*	*VL*	…	*VL*	ν_{22}	
…	…	…	…	…	…	
r_{2N_2}	*VL*	*VL*	…	*L*	ν_{2N_2}	
…	…	…	…	…	…	…
r_{71}	*EH*	*H*	…	*EH*	ν_{71}	$CA_i^k = EH$
r_{72}	*H*	*EH*	. . .	*EH*	ν_{72}	
…	…	…	…	…	…	
r_{7N_7}	*EH*	*EH*	…	*EH*	ν_{7N_7}	

3. Aggregation of fuzzy values of competitiveness of business models of competing enterprises, obtained from experts on the basis of fuzzy derivation by Mamdani, is carried out by the formula $\tilde{CA}_i = \frac{1}{K} \bigoplus_{k=1}^{K} \tilde{CA}_i^k$.

4. Defuzzification of fuzzy values of the competitiveness of business models of competing enterprises (for this purpose, for a fuzzy number $\tilde{u}(a; b; c)$ can be used the CoA method (Center of Area method)) [17] and the following formula:

$$def(\tilde{u}) = \frac{(c-a)+(b-a)}{3} + a \quad . \tag{4}$$

Stage 9. At this stage competing enterprises should be ranked by coordinating the evaluations obtained from both schemes, and taking into account the graphical interpretation (Figure 5), and strategic recommendations for improving the business model of the enterprise under study are developed.

For the practical application of the proposed methodological approach in the Matlab computer system, a framework was developed, the main blocks of which are shown in Figure 7. With the help of this structure, simulations can be performed depending on the adjustment of expert considerations both regarding the importance of the BMC criteria and the scores of competing enterprises on these criteria.

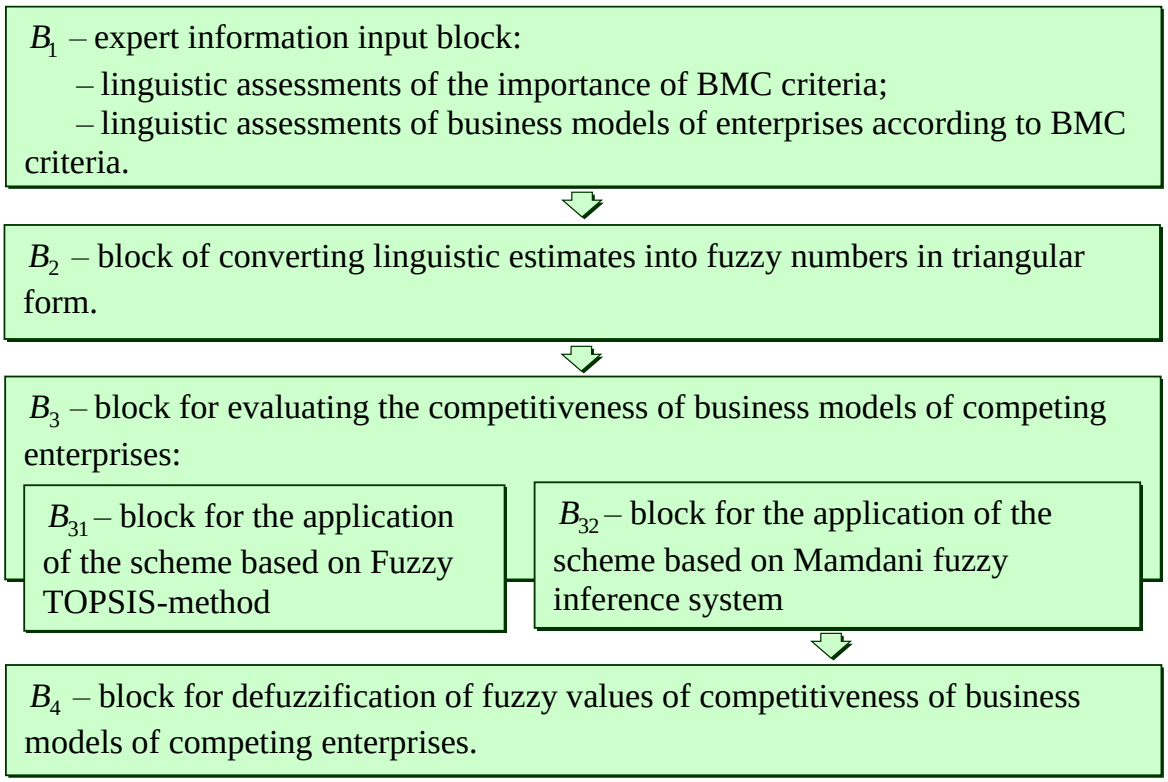

Figure 7. The main blocks of the developed methodological approach to assessing the competitiveness of business models of enterprises

Source: developed by the author

Conclusions

The need to improve the existing tools of strategic management and, in particular, competitive analysis of enterprises due to the increasing complexity, dynamism and turbulence of the processes taking place in most sectors of the world economy, as well as the global impact on these processes of the long-term pandemic coronavirus. An important component of the methodology of competitive analysis is the analysis and evaluation of the competitiveness of enterprises and their business models, which require new approaches and methods that can take into account the multi-criteria nature of the relevant procedures, the subjectivity and ambiguity of the raw data, opinions and judgments of experts involved in these procedures. In the last decade an extremely promising direction in strategic management for solving the problems of strategic analysis of the enterprise is the use of fuzzy sets theory and fuzzy logic, which have expanded the capabilities of classical tools and demonstrated their effectiveness and flexibility. Accordingly, fuzzy methodology (fuzzy multicriteria analysis and fuzzy logic) became the basis for solving the problems of this study. To form a system of criteria for assessing the competitiveness of business models of enterprises, a thorough analysis of the factors and criteria that determine the competitive advantages of the business model of the enterprise as part of its overall competitiveness was carried out. It is concluded that the system of Canvas business model criteria proposed by Osterwalder and Pigneur is the most complete and effective. The developed methodological approach contains two calculation schemes for assessing the competitiveness of business models of enterprises (based on the Fuzzy TOPSIS-method and Mamdani fuzzy inference system). Linguistic assessments of the importance of the criteria of BMK and competing enterprises are carried out using a seven-level set of terms, each term of which is represented by a fuzzy number in a triangular form and has a triangular form of the membership function. In case of significant differences in experts' opinions, it is recommended to use the Fuzzy Delphi method for their reconciliation. For the practical application of the proposed algorithm, a structure was developed that converts the linguistic evaluations of experts into fuzzy numbers, fully implements both calculation schemes, allows for simulation depending on the adjustment of expert considerations, and can serve as the basis for the creation of appropriate management support systems.

The developed methodological approach can become an effective and efficient tool in the competitive analysis to identify the competitive advantages of the business model by the management of the enterprise, the justification of strategic measures to improve it and the choice of competitive strategy in the market.

Further research on the topic of this study can be aimed at improving the following components of the proposed methodological approach: selection of members of the expert group based on their competence and experience in the subject area, improving the system of evaluation criteria. An applied task can

be the testing of this methodological approach to assess the competitiveness of business models of enterprises, taking into account the specifics of the industry and markets in which they operate.

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