ZERO-BASED BUDGET IN RESTRICTIVE CONTEXTS: WORK METHODOLOGY APPLYING FUZZY LOGIC FOR SMES

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Abstract

Purpose: *The objective of the research is proposed a methodology to prepare a Zero-Based Budget (ZBB) for Small and Medium-sized Enterprises (SMEs) in Ecuador, applying fuzzy logic.*

Design/methodology/approach: *A quantitative approach is assumed to show findings derived from the work carried out in these Ecuadorian business units, belonging to non-essential sectors such as wood, textiles and footwear. Fuzzy logic, the technique of expertise, and Trapezoidal Fuzzy Numbers (TpFN) are used to capture true budget levels.*

Findings: *The results recommend that optimal budget levels can be obtained for SMEs in restrictive and health emergency contexts.*

Originality/value: *As a result of COVID-19 pandemic, markets and demand are contracting causing variations in income and demanding greater rationalization at the level of expenditures. For SMEs is essential prepared income and disbursements estimates. Based on the methodology proposed, predictions are made to achieve the objectives of SMEs. Directors will be able to make more successful decisions for the benefit of their companies, to streamline operations, direct the achievement of objectives, rationalize expenses (costs and expenses), and to project better scenarios in the future before carrying out cost-benefit analysis.*

Keywords: *zero-based budget; fuzzy logic; trapezoidal fuzzy numbers; SMEs; COVID-19*

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1. Introduction

The pandemic situation caused by COVID-19 has disrupted the normal flow of operations (Valencia and Chiatchoua, 2021), markets have contracted and the demand for non-essential items has fallen, causing a reduction in sales and income (Valencia and Chiatchoua, 2021). This situation strongly affects Small and Medium-sized Enterprises (SMEs), particularly in production operations, finance (Valencia and Chiatchoua, 2021) and human talent.

The low levels of sales are evident in non-priority sectors such as timber (carpentry), textiles, and footwear. According the Survey on the Economic Impact Generated by COVID-19 on Companies (ECOVID-IE) in 2020, out of a total of 1,873,564 companies surveyed, 93.2% reported having been affected by a decrease in income, reduction in demand or shortage of inputs, due to the pandemic

(INEGI, 2020). The contraction in operations affects their profitability and permanence in the market.

Based on these results, reforming work methodologies, innovating and redefining strategies (Arbussa *et al.*, Bikfalvi and Marquès, 2017; Madrid-Guijarro *et al.*, 2016) becomes essential to face current challenges, and promote its reactivation and maintenance in the sector; that is to say, to work thinking of avoiding extinction. It is necessary to put management tools into practice and make decisions that project activity in restrictive, contracted and volatile periods

SMEs are part of the industrial sector in Ecuador, particularly in Cuenca, province of Azuay, considered one of the largest and most populated cities in the country, which gathers SMEs engaged in different economic activities. This industrial sector has shown dynamism in pre-pandemic times, generating significant contributions to the economic and social development of the city and the country; however, this reality changes in times of pandemic.

According to the International Monetary Fund (2020), Ecuador, the eighth largest economy in Latin America, has contracted by 10.9%. In the years 2019-2020, the Gross Domestic Product (GDP) falls and goes from 7.3% and 9.6%, (Banco Central de Ecuador, 2020). The country's economic recession is reflected in financial indicators and the volatility of its economy. Projected in post-pandemic scenarios, the SMEs of this region require an immediate economic and financial reactivation, in order to boost their activity and dynamize their operations. Also, to have an adequate and efficient consideration of disbursements to enhance their rationalization and achieve greater efficiency and profitability from an economic perspective. In these scenarios, the estimation of income and expenses plays a preponderant role, which requires managing resources that are considered scarce.

Budgets are an integral part of short-term planning and control in most organizations (Merchant, 1981, cited by Francis-Gladney *et al.*, 2004; Hofmann *et al.*, 2012; Davila, 2000). They represent valuable instruments for financial management, necessary in decision-making processes and in the coordination of actions to be taken (Doxey, 2019 and 2021). Budgets are projected with high reliability and they allow observing the exercise of institutional resources (Jáuregui, 2014) with efficiency, equity and quality (Franciskovic, 2013). The elaboration of budgets, as monetary expression of the plan, guides the concretion and achievement of objectives in established periods, providing for the implementation of the necessary strategies to achieve them (Burbano, 2011).

The ZBB dates from 1960 (Gil-Lafuente *et al.*, 2015; González *et al.*, 2017; Ma, 2006), and it is projected on this occasion in combination with fuzzy logic, to show decision alternatives to direct behaviors in restrictive scenarios, which guide assertive and efficient decision making. Establishing priority goals will project a future from a greater economic-financial certainty.

The ZBB overcomes traditional views, leaves aside histories of previous years that reflect subjectivity in decision making and inaccuracies in the estimates made. Under this work methodology, the allocation of funds is made according to efficiency and necessity to achieve objectives (Pequeño and Betolaza, 2017; Choi *et al.*, 2021; González *et al.*, 2016), and although it has experienced numerous failures, it remains in force and is applied with moderate achievements in certain environments (Ma, 2006).

By combining ZBB with fuzzy logic, an intelligent system is obtained that projects more reliable figures to support the decision-making process (Villeta *et al.*, 2012), fuzzy logic allows modeling procedural knowledge in certain tasks (Zadeh, 1965), being an alternative reasoning to classical logic (Zadeh, 2008). The idea is to capture the economic dynamics of SMEs, through the fulfillment of the objectives set, optimizing costs to achieve goals in the medium and long term. Fuzzy logic is presented as an excellent performance meter for financial ratios, helping evaluators to make better decisions (Diaz *et al.*, 2017), adjusting fuzzy variables according to various situations (Poornikoo and Qureshi, 2019).

The aim of the research is to propose a methodology for the elaboration of the ZBB in SMEs in Ecuador applying fuzzy logic, with the purpose of projecting an adequate financial planning process, achieving a correct distribution of resources, rationalizing expenditures to those only necessary, and complying with goals according to the objectives set. It supposes to deploy from the fuzzy logic, thresholds of action that guarantee greater certainty and precision at the level of the decisions made by managers.

2. Literature Review

Despite all the criticisms made of the budget during the last decades, this instrument remains fundamental in a company's management control system (Panteleeva, 2016; Zor *et al.*, 2018; González *et al.*, 2016), maintaining a privileged place in managerial practice. These fulfill the budget management cycle, which requires planning - budget development, control - variance analysis, and feedback - corrective action (Messer, 2020; González *et al.*, 2016). Budgeting, as any control technique, (Ramón-Jerónimo *et al.*, 2017) facilitates the management of organizations and the fulfillment of their strategic objectives (Naranjo, 2010; Gil-Lafuente *et al.*, 2015).

Among the different types of budgets (Gil-Lafuente *et al.*, 2015), the ZBB is widely used in companies and government agencies (Khalifa and Alodhaib, 2021). It is aimed at responding to administrative needs of governments (Pérez, 2015; González *et al.*, 2017; Ma, 2006; Khalifa and Alodhaib, 2021), representing for this type of institutions an effective scope of application for this tool. However, this is not a limiting factor for private sector organizations to adopt it in their management activities. In this context, although there are limitations in its application (Ma, 2006), there are also benefits, especially when combined with fuzzy logic. It is possible to enhance performance under decisional thresholds aimed at organizational efficiency and profitability. According to Khalifa and Alodhaib (2021), modeling ZBB in a fuzzy environment can eliminate one or several decision centers, considering in the optimal allocation of resources only the most efficient departments, under the premise of healthy budgets.

The ZBB, instead of wondering each year the volume of additional financial resources to allocate to a multiplicity of actions and programs, asks what to do with the available funds, seeking to highlight what is truly a priority, of greater impact in economic and social terms, and measurable in its results (Ciscomani, 2015; Gil-Lafuente *et al.*, 2015). It determines a new level of resource allocation in the organization or some part of it (Chávez, 2015).

The ZBB prepares decision packages, while selecting and ranking such packages to establish hierarchical priorities among different alternatives. The idea is to maximize the achievement of the defined objectives, within a threshold (maximum or minimum limit) with the restrictions faced by the decision-maker for the achievement of his objectives (Gil-Lafuente, 2015). The ZBB bases its success on essential premises that consolidate it as the methodology par excellence in the mission of making organizations more competitive and productive, having as its axis the effective management of expenditure (Sánchez, 2015).

Regarding fuzzy logic, Zadeh (1965; 2008) projects it as part of artificial intelligence, considering it widely used for its theoretical contributions and the development of applications (Díaz *et al.*, 2017), as a complementary alternative to the probabilistic approach (Milanesi, 2016). It is a mathematical technique that aims to emulate the ability that some people have, to make correct decisions from vague or imprecise data, linguistically expressed (Díaz *et al.*, 2014; Tinto *et al.*, 2016; Metaxiotis *et al.*, 2003), relying on reasoning processes based on the observation of human behavior (Bennajeh and Ben Said, 2021). Despite facing imperfect situations with certain uncertainties and inaccuracies (Díaz *et al.*, 2017; Dostál and Chia-Yang, 2018; Plessis *et al.*, 2018), it makes correct decisions as an individual. As a tool, it proposes measurement and analysis systems that decrease the incidence of uncertainty in decision-making processes (Arango, 2012), being widely applied in various branches of information processing (Shnaider and Yosef, 2018).

Fuzzy logic handles imprecise information, in terms of fuzzy sets that are combined in rules to define actions; it relies on mathematical models to provide answers that help to face decision problems in the field of business activity (Muñoz *et al.*, 2016). It uses novel techniques that support the adequate treatment of uncertainty such as confidence intervals, confidence triples, fuzzy subsets and experts (Casanovas and Fernández, 2003) and maintains as a premise that fuzzy concepts derive from fuzzy phenomena that commonly occur in the real world (Kantardzic, 2019), proving to be an adequate framework to handle contradictions (Madrid and Ojeda-Aciego, 2021).

In this research, the combination of fuzzy logic with ZBB specifies, among its advantages (Báez and Bravo, 2020): 1) formalization and simulation of expert reports in the conduction and standardization of a process; 2) provides simple answers to difficult modeling procedures; 3) takes into consideration several variables and their weighted fusion determines the magnitude of the influence; 4) continuously considers cases or exceptions of different nature, integrating them in the solution; 5)

allows the implementation of multi-criteria strategies incorporating the knowledge of experts.

Specifically, the central hypothesis of the research is outlined as follows:

H_0: Zero-Based Budgeting, supported by fuzzy logic, allows SMEs to make optimal and accurate decisions, based on previously defined thresholds, taking advantage of available resources efficiently in restrictive contexts.

In Zero-Based Budgeting, each expense (and income stream) must be explained and justified annually, and in its entirety to senior management (Messer, 2020). In this type of budget, substantive adjustments are made to expenditures (Tovar, 2015), and it is assumed to be one of the most important tools for business and social development (Tacuba, 2016), as it allows concentrating productive programs that address specific problems.

The ZBB: 1) is a methodology that provides detailed information on the resources required to achieve the desired objectives, 2) outlines concrete goals based on a company's priorities and, 3) defines to which items these resources will be directed. By performing a cost-benefit analysis to avoid duplication of functions and programs, based on the design of decision packages, a function or a specific activity can be described, which helps to evaluate and rank it in comparison with other activities.

These tools allow reevaluating programs and expenditures always starting from zero, evaluating and justifying the amount and need of each area and each program when the agencies are spending more than necessary, and incorporating the evaluation in the preparation stage and not only in the results stage (Tacuba, 2016). In other words, it is managed under the principle of administration or management by objectives, leading efforts towards the achievement of goals, directing resources with greater certainty towards their realization.

H_1: Zero-Based Budgeting, based on fuzzy logic, eliminates inertial and discretionary budget allocation criteria.

The ZBB follows an accounting approach oriented to operational efficiency and business redirection through strategic management, is accompanied by long-term savings, cost optimization and investment in innovation (Tacuba and Chávez, 2018), the latter essential in difficult and challenging times when revenues and growth are reduced (Madrid-Guijarro *et al.*, 2016).

H_2: Zero-Based Budgeting, supported by fuzzy logic, allows the allocation of resources to SME objectives by prioritizing them;

The ZBB is built based on programs, and their impact on revenues and problem solving (Huerta, 2016; Brotons and Sansalvador, 2015), however in contexts of high uncertainty such as the current ones (pandemic resulting from COVID-19) the situation of institutions changes, even more so that of small and medium-sized enterprises.

H_3: Zero-Based Budgeting, supported by fuzzy logic, allows for periodic re-evaluation of objectives based on predetermined thresholds for decision-making.

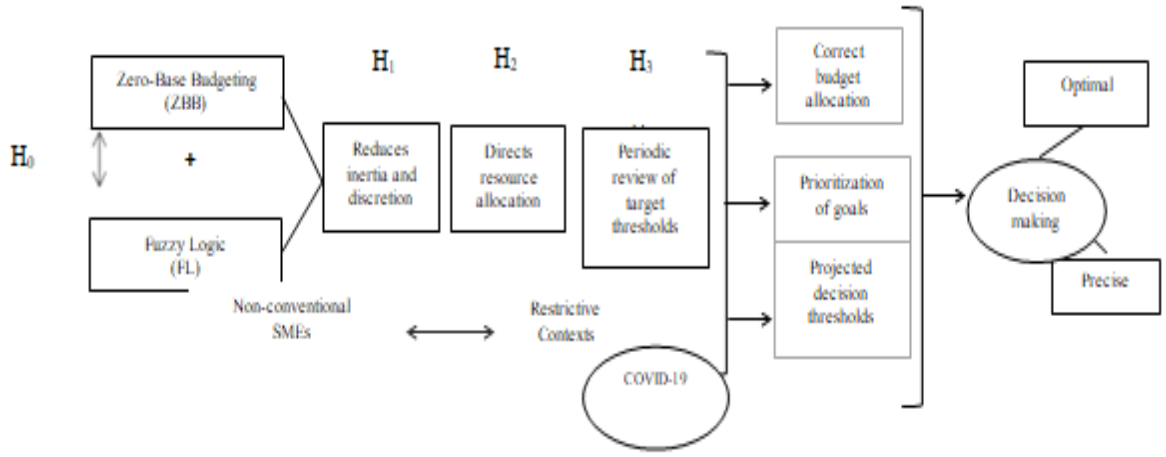
The combination of ZBB with fuzzy logic projects decision thresholds from the highest certainty, optimizing resources and directing objectives towards what is essential in companies, particularly SMEs. Discretionally is avoided, and resources are projected towards what is really important and crucial in the companies.

In the organizational context, companies are subjective units, which perform in dissonant, imprecise, vague, ambiguous, inaccurate and uncertain or probabilistic realities by nature (Restrepo and Vanegas, 2015). Fuzzy logic is projected to handle the present uncertainty, based on the non-linear correspondence between one or several input variables and an output variable, facilitating a basis from which decisions can be made or patterns can be defined that are represented by non-exact values (Flores and García, 2013). It is precisely these situations where the application of fuzzy mathematics (triangular fuzzy numbers and fuzzy subsets) is proposed as a way of dealing with the uncertainty prevailing in the context.

Under a theoretical-hypothetical relationship, the following model for the research is specified as it is shown in Diagram I.

Diagram I

Theoretical-Hypothetical Model



Source: own elaboration

3. Methodology

Fuzzy numbers as a finite or infinite sequence of confidence intervals represent one of the greatest contributions to the knowledge of fuzzy logic, being of great support and benefit for the development of knowledge (Kaufmann and Gil-Aluja, 1987). From this perspective, the theory of fuzzy subsets is applied to business management for the treatment of uncertainty (Kaufmann and Gil-Aluja, 1986), that is, fuzzy logic is incorporated into organizational problems.

Lazzari (1997) explains that an TrFN is determined only by four real numbers (the minimum value, the maximum value and the values of the highest level of assumption); the TrFN will represent the opinion of experts in a wider range. According to Solano (2019), by using tools supported by mathematical models, the assumptions about the relationships between variables and elements of the complex real system could be simplified.

The structure of the ZBB will be based on the application of TpFN, representative values between which a certain event can occur. In this way, the objectives to be achieved in the next period by each department of the company are established, with the purpose of making future predictions based on the TpFN, a fuzzy logic technique. The information is derived from a survey of key personnel in each area of the organization, as well as managers and administrators familiar with the daily management of the company.

Based on the above, the research is inserted in the quantitative plane, it is predictive and projective, and it applies advanced tools offered by fuzzy logic, such as the technique of expertization and TrFN; tools that try to reduce uncertainty with the desired degree of certainty for the future (Luna *et al.*, 2018; Tinto *et al.*, 2016).

4. Results

Within fuzzy logic, one of the most widely used tools of expertizing is the hendecadarian scale used to reduce uncertainty and adjust examined values (Alvarez *et al.*, 2020). Rico and Tinto (2010), propose the use of techniques developed based on the theory of fuzzy subsets, such as expertizing-counter-expertizing, and the theory of forgotten effects in the ex-post treatment of traditional accounting information, with the aim of improving its capacity to support appropriate medium and long-term decision making.

On this basis, Kaufmann and Gil-Aluja (1989), establish that the incidence of one variable with another is expressed by the matrix of forgotten effects, including a greater number of incidences considered as fuzzy elements with a valuation of [0, 1] within an hendecadarian scale, represented at unity as maximum incidence and at zero with no incidence.

The ZBB concept, applying fuzzy logic, expresses the magnitudes corresponding to future periods (Gil-Lafuente *et al.*, 2015). They are data estimated by experts, in one of the most common forms in

the field of uncertainty; TrFN, in addition to this, expose a fuzzy constraint to the overall budget and a criterion for selecting the most appropriate budget for the organization.

The development of a ZBB for a manufacturing company, directs its structure to capture the economic dynamics, optimizing costs to achieve goals in a given period (Luna *et al.*, 2018). Fuzzy logic systems are more flexible and accept the imprecision, subjectivity and vagueness (uncertainty) of the data, allowing to obtain effective solutions to support, in an appropriate way, decision making (Rico and Tinto, 2008).

For the valuation of expert opinion, we resort to the nomenclature introduced by Kaufmann and Gil-Aluja (1989), who state that the introduction of a nuanced valuation between 0 and 1 makes it possible to intervene levels of truth in the notion of incidence: (...) Values from 0 to 1 (the so-called hendecadarian valuation). The principle of Gradual Simultaneity (Kaufmann and Gil-Aluja, 1986) considers that any proposition can be true and false at the same time, as long as one degree is given to truth and one degree to falsehood. Use a real number between 0 and 1, which is simpler and much closer to the skillful way of thinking of man, rehabilitating subjectivism and imprecision (Salazar-Garza, 2012). The hendecadarian scale used for this study is presented in Table I.

Table I. Hendecadarian Scale

PRESUMPTION GRADE α	INCIDENCE
0	Low
0.1	Virtually low
0.2	Very low
0.3	Fairly low
0.4	Lower than high
0.5	As low as high
0.6	Higher than low
0.7	Fairly high
0.8	Very high
0.9	Nearly high
1	High

Source: own elaboration

The first step for the design of the ZBB with fuzzy logic is to outline the objectives to be achieved in the next financial period. As an illustrative example, it is presented for the industrial company "A" in Cuenca (Ecuador); we had the support of key personnel from different areas of the organization, considering the economic and health reality currently faced. Table II shows the objectives to be achieved.

Table II. Objectives to be achieved

N°	Objectives
1	Train personnel in the technological field.
2	Increase production margin.
3	Increase market share.
4	Orient marketing processes to new market niches.
5	Incorporate biosafety elements in the work environment.
6	Launch products with new designs.
7	Optimize teleworking.
8	Apply for credit financing from public or private banks.
9	Create innovative management models.
10	Modernize after-sales service.
11	Use social networks for better product positioning.

12	Improve return on investment.
13	Increase customer satisfaction.
14	Optimize costs and expenses.
15	Improve the company's image.
16	Promote job stability.

Source: own elaboration

Once the objectives to be met have been defined, the next step is to develop the technique of fuzzy logic expertise. This tool tries to reduce uncertainty in the information. Luna and Sarmiento (2019) argue that expertise implies the consultation of a defined group of experts in affinity with a given topic, with the intention of limiting uncertainty. For its application in the case under development, the opinion received from 12 officials from different areas of the company is considered, who, according to their opinion, determined the importance of the objectives outlined (Table II), according to the hendecadarian scale (Table I).

As an example, the steps of this technique are presented in relation to the first objective "To train personnel in the technological area". Table III shows the opinion of each of the experts regarding the importance of the first objective. As can be seen in Table III, the responses of 0.6 and 0.7 are repeated twice; 0.8 is repeated five times; 0.9 is repeated twice; and 1 is repeated four times.

Table III. Opinions of expert officials in relation to the objective "To train staff in the technological field".

Respondent	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Response	0.8	1	1	0.9	0.7	0.6	0.8	0.8	0.8	0.9	0.6	1	1	0.8	0.7

Source: own elaboration

Next, frequency normalization is performed; this consists of dividing the frequency values reached in each degree of presumption of the hendecadarian scale by the number of experts (15), thus 2÷15 = 0.133; 5÷15 = 0.333; and 4÷15 = 0.267. The frequencies are accumulated, starting with the summation from the end of the series, until the unit is obtained, from then on, all the values are considered as one (1.00), as shown in Table IV.

Table IV. Normalization and Frequencies Accumulation

DEGREE OF PRESUMPTION α	FREQUENCY	NORMALIZATION OF FREQUENCY	ACCUMULATION OF FREQUENCIES
0	0	0.000	1.000
0.1	0	0.000	1.000
0.2	0	0.000	1.000
0.3	0	0.000	1.000
0.4	0	0.000	1.000
0.5	0	0.000	1.000
0.6	2/15	0.133	1.000
0.7	2/15	0.133	0.867
0.8	5/15	0.333	0.733
0.9	2/15	0.133	0.400
1	4/15	0.267	0.267
TOTAL			8.267
		EXPERTIZED VALUE	0.827

Source: own elaboration

The total obtained in the sum of the accumulation of frequencies is divided by 10, which corresponds to the factors that form the degree of presumption from 0.1 to 1, giving as a result: 8.267 ÷ 10 = 0.827. This value represents the aggregate opinion of the fifteen experts consulted on the impact of

the objective "To train personnel in the technological field". This technique is developed in a similar way for the other objectives. The results obtained are shown in Table V.

Table V. Threshold determination

N°	Objectives	Threshold
1	Train personnel in the technological field.	0.827
2	Increase production margin.	0.833
3	Increase market share.	0.593
4	Orient marketing processes to new market niches.	0.813
5	Incorporate biosafety elements in the work environment.	0.760
6	Launch products with new designs.	0.647
7	Optimize teleworking.	0.880
8	Apply for credit financing from public or private banks.	0.793
9	Create innovative management models.	0.593
10	Modernize after-sales service.	0.820
11	Use social networks to better position the product.	0.833
12	Improve return on investment.	0.573
13	Increase customer satisfaction.	0.613
14	Optimize costs and expenses.	0.813
15	Improve the company's image.	0.540
16	Promote job stability.	0.613

Source: own elaboration

In order to define the objectives to be considered in the ZBB, information was gathered from twelve experts in charge of decision making within the company. The opinion provided was again based on the hendecadarian scale, through the application of confidence intervals, represented by a minimum and maximum value (Table VI).

Table VI. Expert opinion
"Train staff in the technological field."

EXPERTS	RESPONSES
1	[0.5 ; 0.9]
2	[0.6 ; 0.8]
3	[0.7 ; 0.8]
4	[0.4 ; 1.0]
5	[0.5 ; 1.0]
6	[0.7 ; 1.0]
7	[0.7 ; 0.7]
8	[0.5 ; 0.6]
9	[0.5 ; 0.8]
10	[0.6 ; 0.9]
11	[0.4 ; 0.7]
12	[0.4 ; 0.9]

Source: own elaboration

The same procedure of the expert assessment technique explained is followed to find the aggregate opinion of the twelve experts, related to the importance of the first objective (Table VII).

Table VII. Normalization and Frequencies Accumulation

DEGREE OF PRESUMPTION α	FREQUENCY		NORMALIZATION OF FREQUENCY		ACCUMULATION OF FREQUENCIES	
0.0	0	0	0.00	0.00	1.00	1.00
0.1	0	0	0.00	0.00	1.00	1.00
v0.2	0	0	0.00	0.00	1.00	1.00
0.3	0	0	0.00	0.00	1.00	1.00
0.4	3	0	0.25	0.00	1.00	1.00
0.5	4	0	0.33	0.00	0.75	1.00
0.6	2	1	0.17	0.08	0.42	1.00
0.7	3	2	0.25	0.17	0.25	0.92
0.8	0	3	0.00	0.25	0.00	0.75
0.9	0	3	0.00	0.25	0.00	0.50
1.0	0	3	0.00	0.25	0.00	0.25
TOTAL	12	12	1.00	1.00	5.42	8.42
			EXPERTIZED VALUES		0.54	0.84

Source: own elaboration

In a similar way, this procedure is carried out for all the objectives set, in order to determine the most suitable objectives, which are considered as approved. For this purpose, the thresholds determined in the first expert appraisal must be within the confidence band or interval to be accepted; otherwise, they will not be taken into consideration; the approved ones will be the objectives pursued by the organization through the ZBB. Considering the idea of Agner (2020) in the budget area, it is key to designate a dedicated budget analyst to manage and monitor the transition and activation budget cost center(s) in order to coordinate resources and schedule staff. It will also produce consistent budget tracking and reporting (Table VIII).

Table VIII. Objectives Approval

N°	Objectives	Threshold	INTERVALS	RESULTS
1	Train personnel in the technological field.	0.827	[0.54 ; 0.84]	Approved
2	Increase production margin.	0.833	[0.67 ; 0.89]	Approved
3	Increase market share.	0.593	[0.62 ; 0.88]	Denied
4	Orient marketing processes to new market niches.	0.813	[0.54 ; 0.85]	Approved
5	Incorporate biosafety elements in the work environment.	0.760	[0.71 ; 0.85]	Approved
6	Launch products with new designs	0.647	[0.73 ; 0.89]	Denied
7	Optimize teleworking	0.880	[0.82 ; 0.90]	Approved
8	Apply for credit financing from public or private banks.	0.793	[0.74 ; 0.96]	Approved
9	Create innovative management models	0.593	[0.65 ; 0.79]	Denied
10	Modernize after-sales service	0.820	[0.80 ; 0.93]	Approved
11	Use social networks for better product positioning	0.833	[0.81 ; 0.95]	Approved
12	Improve return on investment	0.573	[0.64 ; 0.89]	Denied
13	Increase customer satisfaction	0.613	[0.73 ; 0.86]	Denied
14	Optimize costs and expenses	0.813	[0.74 ; 0.91]	Approved
15	Improve company image	0.540	[0.66 ; 0.81]	Denied
16	Promote job stability	0.613	[0.72 ; 0.93]	Denied

Source: own elaboration

When projecting the ZBB with TpFN, it is structured based on the approved objectives (Table VII). These were determined considering the most important priorities of the company in order to achieve economic reactivation. Subsequently, the economic resources to be delivered for the fulfillment of these objectives are defined. The budget mentioned above is reported in Table IX.

Table IX. Budget allocation by objective

N°	Delineated Objectives	Budget allocation (US$)
1	Train personnel in the technological field.	3,200
2	Increase the production margin.	7,300
3	Orient marketing processes to new market niches.	2,500
4	Incorporate biosafety elements in the work environment.	3,800
5	Optimize teleworking.	1,300
6	Apply for credit financing from public or private banks.	1,000
7	Modernize after-sales service	3,200
8	Use social networks to better position the product.	2,000
9	Optimize costs and expenses	1,200
	TOTAL	**25,500**

Source: own elaboration

The total budgeted value is determined as the sum of the budget allocation of all the objectives to be met. This value amounts to US$25,500. The financial department is contacted to determine the revenues that the company would generate at the beginning of the period. Management, based on the estimated revenues, establishes a pessimistic position of US$17,159 and an optimistic one of US$24,000 for meeting the objectives set (Table X).

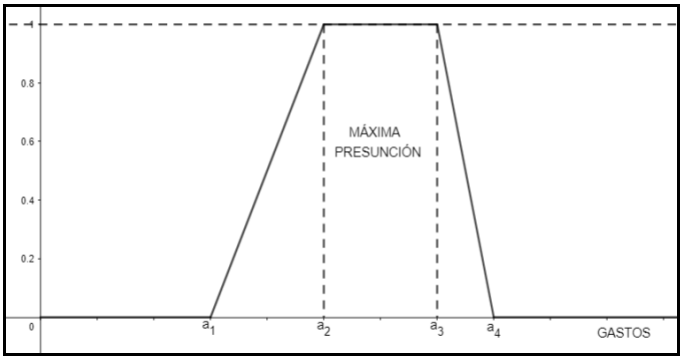
Table X. Estimated revenues

REVENUES COMPONENTS	PESSIMISTIC POSITION (US$)	OPTIMISTIC POSITION (US$)
Unit sales	12,530	14,500
Short-term collections	2,340	3,700
Long-term collections	1,521	2,550
Other income	768	3,250
TOTALS	**17,159**	**24,000**

Source: own elaboration

To represent the organization's budget levels, the TrFN are established, expressed by (a1, [a2, a3], a4), where a1 = lower end; [a2, a3] = maximum assumption; a4 = upper end (Figure I).

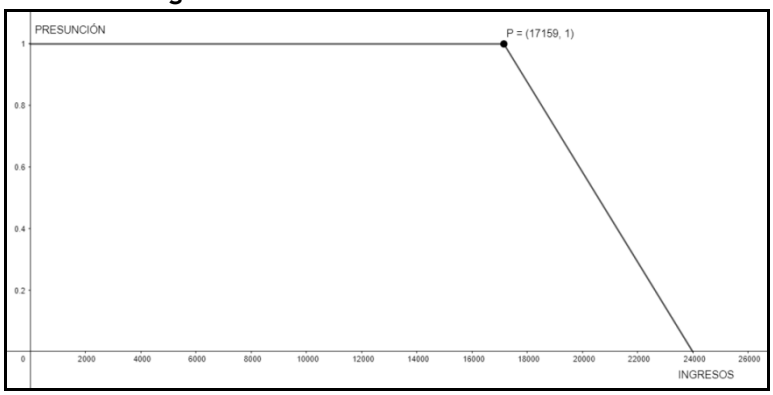
Figure I. Trapezoidal fuzzy number



Source: own elaboration

From Table IX, related to the income that the company would generate, the pessimistic position refers to the certainty of being able to invest in each of the defined objectives. On the other hand, the optimistic position refers to the efforts that will be possible to achieve these objectives. The former takes a valuation related to unity (1) as opposed to the other whose allocation will be zero (0), if it exceeds this value (Figure II).

Figure II. Estimated economic resources



Source: own elaboration

In order to determine the budget levels with their respective assigned items (lower end, maximum assumption, upper end), it is necessary that the experts in the financial area assign these economic values to achieve the objectives set (Table XI).

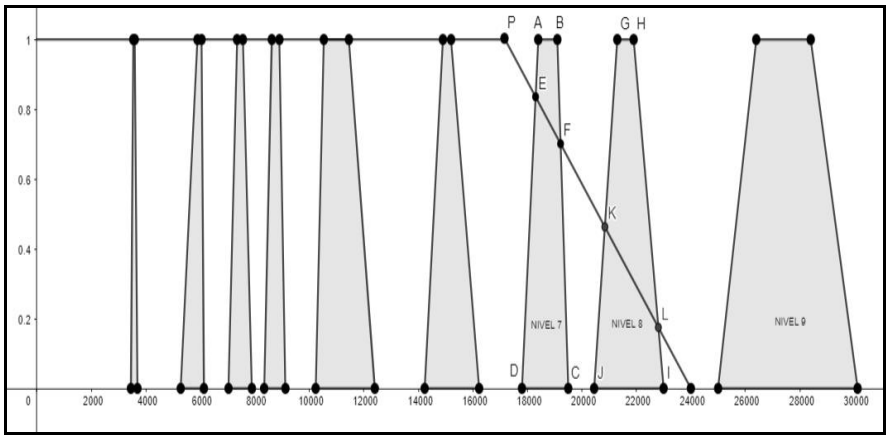
Table XI. Budget levels

LEVELS	ADDING OF LEVELS	TrFN			
		a_1	a_2	a_3	a_4
		(US$)			
LEVEL 1	A_1	3,450	3,536	3,590	3,690
LEVEL 2	$A_1 + A_2$	5,278	5,893	6,043	6,130
LEVEL 3	$A_1 + A_2 + A_3$	7,032	7,345	7,560	7,890
LEVEL 4	$A_1 + A_2 + A_3 + A_4$	8,340	8,620	8,900	9,120
LEVEL 5	$A_1 + A_2 + A_3 + A_4 + A_5$	10,230	10,530	11,450	12,400
LEVEL 6	$A_1 + A_2 + A_3 + A_4 + A_5 + A_6$	14,230	14,900	15,200	16,230
LEVEL 7	$A_1 + A_2 + A_3 + A_4 + A_5 + A_6 + A_7$	17,800	18,300	19,100	19,500
LEVEL 8	$A_1 + A_2 + A_3 + A_4 + A_5 + A_6 + A_7 + A_8$	20,450	21,300	21,900	23,000
LEVEL 9	$A_1 + A_2 + A_3 + A_4 + A_5 + A_6 + A_7 + A_8 + A_9$	25,000	26,400	28,400	30,120

Source: own elaboration

A geometric summary of the nine budgeted levels, which are based on the objectives established for the companies, is presented. They range from Level 1 with an investment of (3,450; [3,536 ; 3,590]; 3,690), US$, to level 9 whose funding will be (25,000; [26,400 ; 28,400]; 30,120), US$. By means of a geometric trace of TrFN, trapezoids are found that identify the budget levels for each objective to be achieved and the corresponding budget constraint. Levels 1 to 6 are accepted, since the budget covers the economic items, while the company's managers, according to their level of coverage, will analyze Levels 7 and 8 while Level 9 will be rejected for not having budget coverage (Figure III).

Figure III. Budgetary level analysis



Source: own elaboration

To determine the lack of coverage index in relation to Level 7, we proceed to calculate geometrically the areas of the trapezoids with the help of GeoGebra software. To do this, the intersection points E and F are found, then the area of the trapezoid ABEF and the trapezoid ABCD is determined, and the coefficient between them, which is called IFC, is determined. Subsequently, the coverage index expressed by IC = 1 - IFC is calculated. In the case of this level, the result is 84.45%, which is a high percentage, so management should approve it.

Lack of coverage index (I_{FC})

$$I_{FC} = \frac{\text{Trapezoid area ABEF}}{\text{Trapezoid area ABCD}}$$

$$I_{FC} = \frac{186.76}{1200.5} = 0.1555$$

$$I_{FC} = 15.55\%$$

Coverage index (I_C)

$$I_C = 1 - I_{FC}$$

$$I_C = 1 - 0.1555 = 0.8445$$

$$I_C = 84.45\%$$

The same procedure is used to determine the coverage index for Level 8. The intersection points K and L are found, the area of the trapezoid GHKL and of the trapezoid GHIJ are calculated, and similarly the CFI and CI are determined, the result of which is 46.62%. In this case, it is left to management to make the decision to approve or reject this budget level.

Lack of coverage index (I_{FC})

$$I_{FC} = \frac{\text{Trapezoid area GHKL}}{\text{Trapezoid area GHIJ}}$$

$$I_{FC} = \frac{840.69}{1575.0} = 0.5338$$

$$I_{FC} = 53.38\%$$

Coverage index (I_C)

$$I_C = 1 - I_{FC}$$

$$I_C = 1 - 0.5338 = 0.4662$$

$$I_C = 46.62\%$$

5. Discussion

The objective of the research is proposed a methodology to prepare a ZBB for SMEs in Ecuador, applying fuzzy logic. As can be seen, with the support of the fuzzy logic technique of expertise, the most suitable objectives that could be achieved by the industrial company of Cuenca (Ecuador) were delimited. Based on this, the ZBB is structured, determining budget levels to achieve as a whole the fulfillment of objectives.

The budget constraint that the organization will have for the following accounting periods was determined with the support of management. This restriction was placed in a pessimistic position of US$17,159 and an optimistic position of US$24,000, in order to meet the defined objectives, it being evident that any value higher than the optimistic position is difficult to meet.

Budget levels 1 to 9 have been structured, with appropriately allocated economic items. Management accepts levels 1 to 6 because they are within the level of coverage. They will cover the necessary requirements to achieve the following objectives: A_1: Train personnel in technology; A_2: Increase the production margin; A_3: Orient marketing processes to new market niches; A_4: Incorporate biosecurity elements in the work environment; A_5: Optimize teleworking; and, A_6: Request financing through loans from public or private banks.

Budget Level 7, with a coverage rate of 84.45%, provides a good margin of compliance to achieve the defined objectives and should therefore be approved by management. The coverage rate for Level 8 is 46.62%, which is a very limited percentage of coverage, and the decision to approve or reject it will be at management's discretion. Level 9 will be rejected because it does not have budgetary coverage.

The application of the TpFN by means of a geometric trace, allows the identification of the budget levels to be reached and the corresponding budget restriction; with this, the company will be able to comply with the delimited objectives to optimize the decision-making processes. This technique represents a valuable tool for SMEs, whose purpose is to analyze, evaluate and allocate economic items in a real and efficient way to the objectives set. It will be possible to visualize an impact on the managers, who will be able to improve the different areas of their company, by means of a more efficient decision-making, favoring its economic reactivation in times of health crisis.

6. Conclusions

SMEs in the industrial sector of Cuenca (Ecuador) must develop work methodologies to activate their operations in recessionary periods and contingency situations. Adopt and adapt new methodologies and work methods, giving priority to what is essentially necessary to keep their operations active and not perish in the attempt; in many situations, starting from scratch, without any preconceptions, was necessary. Structuring a new methodology for preparing a budget makes it possible to meet the expectations set for the following period, i.e., with new processes different from the usual ones within the company.

The ZBB provides a means of meeting the defined objectives, with the purpose of improving decision making and proposing the necessary measures to solve the problems, taking advantage of the resources in an efficient way.

The ZBB, supported with fuzzy logic, incorporates the opinion of experts in the financial area and managers of SMEs, in order to make efficient use in the planning of financial resources, where a thorough analysis is warranted for the assessment and approval of budget levels within a systematization of aspects that encompass objectives whose purpose is to direct the organization to the achievement of its ideals.

The research demonstrated the importance of applying the technique of expertise, typical of fuzzy logic, since it is possible to select the ideal and feasible objectives to achieve the goals set. This makes it possible to reduce uncertainty, trapping the organizational economic dynamics aimed at achieving the objectives, to which economic resources are assigned for execution in the budgeted period. Further research can extend the subject and address related business sectors in other Latin American realities. That comparative studies can be projected and validate the proposed methodology, combining ZBB with support for fuzzy logic in SMEs.

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