



A revisited fuzzy DEMATEL and optimization method for strategy map design under the BSC framework: selection of objectives and relationships

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Abstract

This paper proposes a quantitative method for the selection of strategic objectives and causal relationships to be included in a strategy map of a Balanced Scorecard. A strategy map usually contains the strategic objectives of an organization, grouped into four perspectives: (a) finances, (b) clients, (c) internal processes, and (d) growth and learning, all of them linked through cause-effect relationships. The use of quantitative tools, such as multicriteria decision making, has been proposed to model a strategy map and to select the causal relationships to be included. However, no work has been found in the literature to select the strategic objectives to be incorporated into the map. This is the gap that is addressed in this paper. To overcome this gap, the proposed method incorporates a fuzzy multicriteria method known as DEMATEL (decision-making trial and evaluation laboratory) with an optimization model to choose the strategic objectives and their causal relationships. DEMATEL is used to set priorities to the components of the strategy map, whereas the optimization model selects those to be included by producing the appropriate balance between conflicting goals that appear in building a strategy map (minimum amount of relationships among strategic objectives, maximizing the weight of the relationships/objectives selected). As an illustrative case, the method is applied to a higher education institution where expert judgment in this field provided validation of the strategy map designed.

Keywords Balanced Scorecard · Fuzzy DEMATEL · Strategy maps · Optimization method

1 Introduction

Given the changing environment in which different organizations find themselves nowadays, it is necessary to use control tools, such as the Balanced Scorecard (BSC) (Kaplan and Norton 1992, 1995, 2001a; b) to establish and monitor the objectives of their different strategic areas or units (Martinsons et al. 1999; Bhagwat and Sharma 2007; Tjader et al. 2014; Shaik and Abdul-Kader 2014; Eftimov et al. 2016). The correct implementation of the BSC allows companies to obtain benefits focused on the communication and integration of the strategy to stakeholders; to align individual and collective goals with the organizational strategy; and to create a framework for continuous improvement (Yee-Ching, 2002). Additionally, it enables the company to move from an authority and control structure to one where there is space for the empowerment of employees (Ashton, 1998).

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On the other hand, a proper implementation of the BSC allows a holistic vision of the metrics that are necessary to measure and monitor the organizational performance based on the strategic objectives. Not only does it focus on financial objectives, but it also takes into account different strategic perspectives to make the organization viable (i.e., Financial, Customer, Internal Processes, and Learning and Growth). All these perspectives together connect the metrics with the strategy allowing for a better allocation of resources and monitoring of strategic objectives.

One of the most relevant tasks for the implementation of a BSC is the mapping of strategies, since it provides a structure to demonstrate how strategies link the intangible properties of an organization with the process of creating value and in turn, shows how the objectives of the different perspectives are related to achieving the vision of the organization (Rahimnia and Kargozar 2016). Strategy maps (Kaplan and Norton 2004) are useful in explaining the cause and effect relationships between the different formulated objectives, describing how these objectives work together in the organization processes. In addition, they help to understand better the BSC among employees, create a more significant commitment, allow a fairer evaluation, and reach the strategic objectives via better communication.

Having highlighted the relevance of BSC in organizational strategy, it is important to point out that the literature about the way strategic objectives are defined and selected is scarce. Kaplan and Norton (2004), who developed the BSC, describe the concept of strategic objectives; but they do not propose a method for defining them. The only work found in the literature that proposes a method for defining strategic objectives is the one authored by Quezada et al. (1999). Based on the guidelines produced by Kaplan and Norton (2004), included the proposal by Quezada et al. (1999), managers may define a number of strategic objectives for being included in the strategy map. In addition, previous works have studied methods to select causal relationships in the design of strategy map (Quezada et al. 2014; Quezada and Lopez-Ospina 2014; Acuña-Carvajal et al. 2019). Nevertheless, the selection of strategic objectives based on the set previously defined by decision makers has been a gap in the strategy maps literature.

In-line with those previous studies, this paper contributes to overcome this gap by proposing a method to allow managers to select the strategic objectives from a previously set defined by them. Consequently, it is highlighted that the main contribution of the method in this paper lies in the selection of those objectives that are important as well as the causal relationships between strategic objectives.

In this sense, this research contributes to the formulation of an optimization model for the construction of strategy maps, allowing the selection of the most relevant objectives and relationships for the organization. To achieve this, the fuzzy DEMATEL method was used to obtain the weights of the relationships and objectives. Then, these weights were used as parameters for the optimization model that seeks to minimize the number of resulting relationships considering constraints that let maintaining the logical structure of the maps described by Kaplan and Norton (2004). The optimization model selects relationships and strategic objectives included by producing the appropriate balance between the conflicting goals that are present in the construction of a map (minimum amount of relationships, maximizing the weight of the relationships/objectives selected).

As an illustrative case, the method is applied to the higher education sector where expert judgment in this field provided validation of the chosen objectives for the strategy map. Within this numerical case, we proposed a systematic way to make the sensitivity analysis within the parameters and to analyze the solutions' robustness. In proposing this method, we summarize the contribution of this research in overcoming the limitations of previous methods by integrating the selection of the most important relationships and the most representative strategic objectives, taking into account the subjectivity of the decision makers.

Previous methodological contribution could apply in other organizations that is this research has implications in practice. Hence, the applicability of this research paper targets the appropriate design of strategy maps of any organization, considering that these structures must be aligned and framed to the specific context of each one. In addition, one of the practical implications of this research is to quantify and better understand both the relationships between strategic objectives, as well as the selection of these objectives, and as a consequence, to be able to create continuous improvement processes based on the decisions and actions plans built upon the prioritized objectives. The adequate definition of the relationships and objectives therefore allows the clear designing of indicators and action plans.

To accomplish the methodological and practical contribution of this research, the paper is organized as follows: after the introduction, the second section describes the literature review about BSC in higher education and the use of multicriteria models in BSC. The third section explains the proposed method with the use of fuzzy DEMATEL and the optimization model; the fourth section provides an application in the education sector to illustrate the proposed method; and finally, the fifth section provides theoretical

and practical implications, conclusions and further research.

2 Literature review

The purpose of this literature review is twofold: to assess relevant developments on quantitative methods for the design of strategy maps, and to provide recent applications of BSC in Higher Education Institutions.

2.1 Multicriteria models for designing strategy maps

A strategy map shows how an organization converts its initiatives and resources, including intangible assets, such as corporate culture and employee knowledge, into tangible returns. It also describes the logic of the strategy and highlights the objectives of the critical internal processes that create value and the intangible assets needed to support them (Kaplan and Norton 2004).

Particularly, in the process of formulating and selecting strategic objectives that structure the map, there is a tendency in different sectors to focus to a large extent on financial indicators, leaving aside the other dimensions that are equally important to guarantee differentiating advantages for the organizations (Quezada et al. 2009; Roadprasert et al. 2014; Tichá and Kocourková 2014; Moraga et al. 2020). In addition, in many cases, it is difficult to define, select and/or design these objectives, since organizations tend to have too many (Fernández 2001) that led to poorly design the measurement system (Kaplan 2001). Moreover, there is a need to make an explicit weighting of the strategic objectives, since the BSC methodology assumes that these have the same importance (Chytas et al. 2011). Additionally, in general, there is no formal and objective definition of the causality relationships among the strategic objectives, which means that they depend on the context and are subject to different interpretations by the decision makers, and there is not a broad guide in the literature for constructing strategy maps (Quezada and Lopez-Ospina 2014; López-Ospina et al. 2017).

As shown by Quezada and López-Ospina (2014), López-Ospina et al. (2017) and Acuña-Carvajal et al. (2019), for the implementation of the BSC and in particular, the design of the strategy map, the use of quantitative tools, such as, multicriteria decision making (MCDM) to construction of strategy maps and the analysis of the level of causality between objectives has received more attention. Preliminary studies such as the one proposed by Yang et al. (2008) used DEMATEL (decision-making trial and evaluation laboratory) technique to establish relationships of a causal effect between objectives. Similarly, Jassbi

et al. (2011) used fuzzy DEMATEL to model relationships within a strategy map, without analyzing the construction or design of it. Wu (2012) used DEMATEL to create a strategy map, and other authors such as Tseng (2010), Chen et al. (2011) and Quezada et al. (2018) combined ANP (Analytic Network Process) and DEMATEL to model and analyzed a BSC.

Recent studies involved mathematical optimization models integrated with multicriteria tools to select the most relevant relationships within a strategy map. Quezada and López-Ospina (2014) designed a multi-objective optimization model (i.e., to minimize the number of relationships and maximize the global weighting of the map) using the AHP (Analytic Hierarchy Process) technique for the definition and weighting of the relationships between objectives. López-Ospina et al. (2017) and Acuña-Carvajal et al. (2019) extended these previous works using the DEMATEL and fuzzy DEMATEL technique as an input for the optimization model. These mathematical models aim to minimize the number of relationships between objectives and maximize the importance of the selected strategic objectives.

Although DEMATEL method has been extensively used and well exploited in the literature, its application in the construction of strategy maps has been limited. It is worth mentioning that the studies mentioned above do not have considered combining the elimination or debugging of strategic objectives together with the minimization of causal relationships into strategy mapping framework.

2.2 BSC in higher education

The BSC and the formulation of strategy maps have brought multiple benefits to all types of organizations. Consequently, BSC has been used extensively in companies, governments, and nonprofit organizations (Kaplan et al. 2001; Narayanamma and Lalitha 2016; Miller 2018); . Especially, the success of this methodology has increased the interest from different non-commercial and nonbusiness organizations, such as universities whose effective operation, management, and control materialize in benefits for the capacities and developments of any country (Beard 2009).

In the case of higher education institutions, the adaptation of the BSC has been historically based not on financial measures but on academic measures, and therefore, the classic perspectives of the model has been adjusted to the requirements of universities and other higher education institutions. Sayed (2013) and Ahmad and Kim-Soon (2015), among others, propose establishing the Financial and Clients perspectives at a same level, meaning that the financial performance is not the final objective of the institutions. In the same way, in their survey about

Malaysian Private Institutions of Higher Learning Ariff et al. (2019) they found that most institutions have changed the name of the clients and financial perspectives. The importance of the BSC for this type of organizations relies on the improvement in their performance by linking the mission and strategy with a learning model that allows continuous improvement (Umayal Karpagam and Suganthi 2012). On the other hand, the social impact of higher education institutions is negatively influenced by the poor management of resources which affects the quality of the services provided. The BSC offers an innovative approach for this type of organizations by allowing the optimal management of resources, obtaining the desired results, and strengthening the monitoring and control of the strategic management, all focused on increasing the levels of efficiency and effectiveness in the provision of educational services (Ramírez and Baidez 2011). In turn, the BSC is a useful tool for educational institutions in the process of planning and identifying future needs and in the continuous improvement in quality to promote academic excellence (Al-Hosaini and Sofian 2015). In educational management, BSC has a great potential when reverted into effective strategic management, cohesion of the organization and its employees, organizational synergy, effective decision-making processes, timely responses to a changing environment and competitive advantage of the organization (Eftimov et al. 2016).

Although in the literature there are applications of the BSC in the education sector (Ramírez and Baidez 2011; Martins 2015; Cheowsuwan 2016; Eftimov et al. 2016; de Andrade et al. 2018), these studies remain scarce. In addition, the current literature has their own limitations: applications show that there are scarce indicators that not allow an appropriate decision-making process; excessive emphasis in some perspectives or institutional areas affecting the integration for an effective management; and inadequate monitoring and control of the implementation of institutional strategies. There is also evidence of poor definition of strategic objectives with their not prioritized associated indicators and little discussion from decision makers about the construction of the strategy map, leading to a reduced impact of the strategy (Casero et al. 2010).

3 Proposed method

The proposed method seeks to obtain the relationships between the most relevant objectives within the framework of a strategic map of the BSC, integrated with decisions of debugging/elimination of the less important objectives to achieve the strategic goals of the organization.

The method proposes the integration of a multicriteria method (fuzzy DEMATEL, which obtains the

importance level among the relationships of the objectives) with an optimization model to select both objectives and relationships. In addition, a systematic way to perform sensibility analysis of the parameters is presented, in this way, different strategic maps are defined, and thus different options for the respective organization are provided. Section 3.1 presents a fuzzy version of the revised DEMATEL method, described in its deterministic type in Lee et al. (2013). Section 3.2 presents the proposed optimization model for the objectives and relationships debugging, obtaining the most representative or relevant ones for the strategy.

There are, at least, two advantages for using DEMATEL in this work. First, the strategic objectives and causal relationships fit perfectly with the network of DEMATEL, which means that DEMATEL can be used naturally to represent a strategy map. Second, the application of DEMATEL allows the capture of the complex relationships between the strategic objectives.

The reason for using a multi-objective programming model is due to the fact that the construction of a strategy map has contradictory goals. In one hand, it would be necessary to include as many as causal relationships as possible to take consideration of their influence. But then, if too many of causal relationships are included, the objective of the strategy map would be lost, because it would be too difficult to understand it and it would not represent the organizational strategy. In this way, the mathematical model aims at obtaining the appropriate balance between both purposes.

3.1 Fuzzy DEMATEL method

The DEMATEL method (Decision Making Trial and Evaluation Laboratory) (Fontela and Gabus 1974) consists of a multicriteria method to visualize the structure of complex causal-effect relationships or the analysis criteria. DEMATEL gathers collective knowledge to capture the causal relationships between the strategic criteria, becoming the most effective method, which transforms the relationship between the causes and effects into an intelligible structural model of the system (Lu et al. 2013; Han and Deng 2018; Zhang and Deng 2019; Wu et al. 2020; Yazdani et al. 2020).

Additionally, the causal relationships between the objectives depend on the knowledge and experiences of the strategic decision makers, generating uncertain or ambiguous environments. Therefore, including fuzzy parameters in the DEMATEL model (Jassbi et al. 2011; Valmohammadi and Sofiyabadi 2015; Acuña-Carvajal et al. 2019) adequately solves the decision-making problems of multiple agents and criteria in such uncertain environments. In this paper, the use of the extended

revisited DEMATEL method applying linguistic variables is proposed. The deterministic version of the revisited DEMATEL developed by Lee et al. (2013) shows that the classical method may not converge and thus the matrix of total influence may not be correct. These authors show that the revised DEMATEL guarantees the convergence and the validity of the results. Fuzzy DEMATEL for multicriteria decision method (MCDM) defines the level of relationship between the objectives of the strategy map through linguistic terms, to which fuzzy values are assigned to express the different degrees of influences or causalities. A committee of experts must establish the relationship level between the strategic objectives.

Next, the step-by-step method of fuzzy DEMATEL is presented, based on the proposed structure in the work of Lee et al. (2013) where they formulated a revised version of DEMATEL.

STEP 1: Definition of terms and values for the level of relationship between the strategic objectives.

Based on Jassbi et al. (2011) and Valmohammdi and Sofiyabadi (2015) for the definition of the level of relationship between the strategic objectives, it is evaluated through linguistic terms through fuzzy triangular numbers. That is, each linguistic term takes three values (λ, μ, τ) as shown in the Table 1. These linguistic assessments and values could change depending on the context.

STEP 2: Selection of the expert committee and initial matrix.

Using linguistic scale of step 1 [very-high (VH), high (H), low (L), very-low (VL) and null (N)], A set of P experts are asked about the level of relationship between strategic objectives from the four perspectives. With this valuation, the initial influence matrix is obtained for each expert.

STEP 3: Generation of fuzzy matrices

$$X_p(\lambda, \mu, \tau) = \begin{bmatrix} 0 & x_{12}(\lambda, \mu, \tau) & \cdots & x_{1n}(\lambda, \mu, \tau) \\ x_{21}(\lambda, \mu, \tau) & 0 & \cdots & x_{2n}(\lambda, \mu, \tau) \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1}(\lambda, \mu, \tau) & x_{n2}(\lambda, \mu, \tau) & \cdots & 0 \end{bmatrix}$$

$\forall p \in P$

From the evaluation of the previous step, three matrices are generated by each expert according to the linguistic values (λ, μ, τ) . That is, $X_p(\lambda, \mu, \tau)$ corresponds to three matrices (Jassbi et al. 2011; Wu and Lee 2007; Wu et al. 2011; Wu 2012; Valmohammdi and Sofiyabadi 2015).

STEP 4: Calculation of initial average matrices

$$A(\lambda, \mu, \tau) = \frac{1}{P} \sum_{p=1}^P X_p(\lambda, \mu, \tau). \tag{1}$$

The initial average matrices are calculated from the average of the experts' evaluation for each linguistic value (1). This means that the results of this step will be three matrices one for each linguistic value (λ, μ, τ) , (Lee et al. 2013).

STEP 5: Normalization of initial relation matrices

$$N(\lambda) = \frac{A(\lambda)}{s_\lambda}, \tag{2}$$

where

$$s_\lambda = \max \left(\max_{1 \leq i \leq n} \sum_{j=1}^n a_{ij}(\lambda); \varepsilon + \max_{1 \leq j \leq n} \sum_{i=1}^n a_{ij}(\lambda) \right)$$

$\varepsilon =$ very small number.

The matrices of initial relationships are normalized through the presented formula (2), where $A(\lambda)$ is the average for minimum values (Lee et al. 2013). Equivalently, it is possible to obtain $N(\mu)$ and $N(\tau)$

STEP 6: Calculation of fuzzy matrices of total relationships.

$$\begin{aligned} T(\lambda) &= \sum_i^{\infty} N(\lambda)^i = N(\lambda)(I - N(\lambda))^{-1}; T(\mu) \\ &= \sum_i^{\infty} N(\mu)^i = N(\mu)(I - N(\mu))^{-1}; \\ T(\tau) &= \sum_i^{\infty} N(\tau)^i = N(\tau)(I - N(\tau))^{-1}. \end{aligned} \tag{3}$$

The calculation of matrices of total relationships (direct and indirect relationships) for each linguistic value (λ, μ, τ) is made, according to the formula (3) and this results in the matrix T .

STEP 7: Defusification of matrices of total relationships

Table 1 Description of linguistic valuation

Linguistic term	Linguistic value		
	λ minimum	μ intermediate	τ maximum
Very high (VH)	0.75	1	1
High (H)	0.5	0.75	1
Low (L)	0.25	0.5	0.75
Very low (VL)	0	0.25	0.5
Null (N)	0	0	0.25

$$W = \frac{1}{3}(T(\lambda) + T(\mu) + T(\tau)). \tag{4}$$

Through the Yager index (4) the three matrices of total relationships are unified and the matrix W is obtained, which will be used in the linear programming model proposed in the following section (Saltos and Aceves 2012; Ruan 2012).

STEP 8: Causality analysis

$$D_i = \sum_{j=1}^n W_{ij},$$

$$R_j = \sum_{i=1}^n W_{ij},$$

$$D + R, \tag{5}$$

$$D - R \tag{6}$$

The D_i is calculated as the sum of the rows and R_j as the sum of the columns.

Finally, an analysis of which strategic objectives are the most important (5) and how they are classified (cause or effect) (6) is made. When $D - R$ is negative it means that the target is a strong effect; and when it is positive, the objective is classified as strong cause. It is worth remembering that in a BSC a strategic objective can be cause and effect at the same time.

The $D + R$ value represents the importance of each of the objectives (Wu et al. 2011).

STEP 9: Weighting of strategic objectives.

U_i : the qualification of each strategic objective is calculated taking into account three criteria: whether it is feasible, understandable, and useful (López-Ospina et al. 2017).

3.2 Optimization model

The optimization model aims to minimize the relationships between the strategy map objectives by eliminating those that do not have an important impact on the strategy. In addition, the model selects strategic objectives to be included by producing the appropriate balance between conflicting goals that appear in building a map (minimum amount of relationships among strategic objectives, maximizing the weight of the relationships/objectives selected). A strategy map of a BSC (Kaplan and Norton 2004), considers, without loss of generality, four perspectives with their most relevant relationships (i.e., *learning and growth and internal processes, internal processes and clients and, finally, clients and financial*), each of them associated to the strategic objectives. In this paper, this structure is applied, although the model can be adjusted and implement in other contexts or structures.

Taking into account the critical success factors for an organization, this section presents the relevant sets (i.e., perspectives of the BSC); the decision variables (i.e., binary selection of relationships and objectives); and the associated parameters (weighing between relationships between objectives, weighting of objectives, and others). Following, the objective function and restrictions.

SETS

O = Strategic objectives set

A = Learning objectives set

P = Set of objectives of internal processes

C = Customer objectives set

F = Financial objectives set

DECISION VARIABLES

$$X_{ij} = \begin{cases} 1, & \text{if the relationship between objective } i \\ & \text{and objective } j \text{ is included within the strategic map} \\ 0, & \text{otherwise } \forall i \in O, \forall j \in O \end{cases}$$

$$Y_i = \begin{cases} 1, & \text{if target } i \text{ goes inside strategic map} \\ 0, & \text{otherwise } \forall i \in O \end{cases}$$

PARAMETERS

- W_{ij} = Matrix of total relations between the objectives (obtained in table 1 by the DEMATEL)

- $$R_{ij} = \begin{cases} 1 & \text{if } W_{ij} > 0, \text{ that is, it takes the value of} \\ & 1 \text{ when there is a relationship between objectives} \\ 0, & \text{when there is no relationship or when} \\ & \text{it is not relevant for decision makers)} \end{cases}$$

- $$T_i = \begin{cases} 1 & \text{if it is established that an objective } i \\ & \text{is the cause of someone else} \\ 0, & \text{otherwise} \end{cases}$$

For example, it could be established previously that the objectives of the financial perspective are not the cause of other objectives, that is, if i belongs to F then it is defined that $T_i = 0$.

- $$S_j = \begin{cases} 1 & \text{if (if there is a relationship)} \\ & \text{it is established that an objective } j \\ & \text{is the effect of someone else} \\ 0, & \text{otherwise} \end{cases}$$

For example, it could previously be established that the objectives of the learning perspective are not the effect of

other objectives, that is, if j belongs to A , then it could be that $S_j = 0$.

- U_i = weighting of objective i
- α = Minimum percentage of total relationships between objectives that you want to obtain in the strategy map
- β = Minimum percentage of relations between objectives of contiguous perspectives.

The contiguous perspectives are: learning and growth and internal processes, internal processes and clients and, finally, clients and financial.

- γ = Minimum percentage of the total score of the strategic objectives that will establish how many of them with the highest (most important) qualifications will be included in the strategy map

Note that β , and γ in $[0, 1]$.

The parameters α , β , and γ depend on the decision makers, and it is recommended to make a sensitivity analysis to analyze the robustness of the resulting map. The variation of these parameters is equivalent to design epsilon-constraints of a multi-objective optimization problem.

OBJECTIVE FUNCTION

To minimize the number of strategy map relationships:

$$\min Z = \sum_{\forall i \in O} \sum_{\forall j \in O} X_{ij}$$

Table 2 describes the constraints of the optimization problem.

4 Illustrative application: construction of the strategy map for a higher education institution

This section explains the use of the proposed method in an illustrative case of a Higher Education Institution. It is important to mention that this method can be applied to a strategy map of any organization, taking into account the particularities of each organization.

For the construction of the strategic map, six experts from the same university were consulted to validate the results obtained by the proposed method. These experts were administrative staff and faculty members with practical knowledge of BSC and/or strategy development. They also have had work experience in positions related to academic management in private universities (between 8 and 16 years). The experts' profile is described in Appendix A.

First of all, to have the initial inputs, a literature review was carried out by establishing a list of strategic objectives for each of the four perspectives of the BSC. These

objectives were proposed within the context of higher education institutions. To carry out this first stage, the following steps were executed:

- I. Review of the literature.
- II. Analysis of the common structures of the strategy maps found in the literature.
- III. Selection of the most relevant objectives found in the literature.
- IV. Description of each of the objectives found in the literature.
- V. Classification of the strategic objectives in each of the perspectives.

Following the previous stated steps, a list of strategic objectives was proposed for each of the four perspectives as presented in Table 3. Different studies provided insights to define each objective, which are presented in Appendix B.

As a first step, each of the experts validated the objectives of Table 3. They were asked if each proposed strategic objective was feasible, understandable, and useful for the organization's strategy map (López-Ospina et al. 2017), using a rating scale of 1–10, with 10 being the highest rating. The final rating of each objective was made by adding the scores of the three criteria, divided by the sum of the maximum ratings for each objective. Experts also answered about the degree of relationship that the objectives have among the four perspectives of the BSC.

The step 2 was carried out by establishing the causal relationships among the strategic objectives of the organization. These relationships correspond to the direct influence matrix of DEMATEL. In order to fill in the matrix, each expert was asked to evaluate the influences in the linguistic scale of step 1 [very-high (VH), high (H), low (L), very-low (VL) and null (N)]. As an example, Table 4 shows the direct influence matrix of one of the experts. In this case, the expert states that the achievement of strategic objective "Innovation in teaching and learning" (A2) has a very high influence (VH) on the achievement of strategic objective "Quality in the curriculum" (P5).

As described in the step 3, from each one of the linguistic entries of an initial matrix, 3 numbers are derived. In the example shown in Table 4, to the entry VH, corresponding to the influence of strategic objective A2 on strategic objective P5, is assigned the values: $\lambda = 0.75$, $\mu = 1$ and $\tau = 1$ (see Table 1). In this way, three matrices are obtained, one using the first values, one using the second values and one using the third values. As an example, Table 5 shows the matrix with the first values of the evaluation (λ) presented in Table 4.

Using Eq. (1), the average of the experts' evaluation is calculated for each one of the three matrices. In other words, there will be one average matrix for the first values

Table 2 Description of the constraints of the mathematical model

Nº	Restrictions	Description
1	$\sum_{vi \in O} \sum_{vj \in O} X_{ij} * W_{ij} \geq \alpha * \sum_{vi \in O} \sum_{vj \in O} W_{ij}$	It generates within the map at least $\alpha * 100\%$ of the total relations between the objectives
2	$Y_i T_i \leq \sum_{vj \in O} R_{ij} X_{ij} \forall i \in O$	For the objective j that is the cause of another, if there is a relationship and this is included in the map, the causal objective can be included or not
3	$\sum_{vi \in O} R_{ij} X_{ij} \geq Y_j S_j \forall j \in O$	For the objective j that is the effect of another, if there is a relationship and this is included in the map, the objective effect can be included or not
4	$X_{ij} \leq Y_i \forall i \in O, \forall j \in O$	The i objective can enter the map if there is a relationship with another objective
5	$X_{ij} \leq Y_j \forall i \in O, \forall j \in O$	The objective j can enter the map if there is a relationship with another objective
6	$X_{ij} \leq R_{ij} \forall i \in O, \forall j \in O$	If there is a relationship between objectives, it may or may not be included within the strategy map
7	$X_{ij} + X_{ji} \leq 1 \forall i \in O, \forall j \in O$	These constraints prevent the objectives from being cause and effect at the same time from another objective
8	$\sum_{vi \in A} \sum_{vj \in P} X_{ij} * W_{ij} \geq \beta_{AP} * \sum_{vi \in A} \sum_{vj \in P} W_{ij}$ $\sum_{vi \in P} \sum_{vj \in C} X_{ij} * W_{ij} \geq \beta_{PC} * \sum_{vi \in P} \sum_{vj \in C} W_{ij}$ $\sum_{vi \in C} \sum_{vj \in F} X_{ij} * W_{ij} \geq \beta_{CF} * \sum_{vi \in C} \sum_{vj \in F} W_{ij}$	These constraints generate within the map at least β of the weighting of the relations between objectives of contiguous perspectives The contiguous perspectives are learning and growth and internal processes, internal processes and clients and, finally, clients and financial
9	$\sum_{vi \in O} Y_i * U_i \geq \gamma * \sum_{vi \in O} U_i$	Minimum percentage of the qualification of the selected objectives in the strategy map

(λ), one average matrix for the second values (μ) and one for the third values (τ). As an example, Table 6 displays the average of the matrices of the 6 experts associated to the first value (λ).

Next, matrices of the initial relationships were normalized (see Eq. (2)). In addition, in the step 5, the calculation of matrices of total relationships (direct and indirect relationships) for each linguistic value (λ , μ , and τ) was made, according to the formula (3). For this illustrative application, the total relationships minimum matrix is described in Table 7.

Next, the matrix of total relationships was obtained (step 6) as the result of the revisited fuzzy DEMATEL previously stated using Yager index (4). This following matrix (Fig. 1) shows the level of relationship between the objectives of the different perspectives through a scale of colors from red to green, where red represents the nonexistence of relationships and green shows the strongest relationships.

Based on the results from the previous matrix (Fig. 1), the last step of the DEMATEL technique consisted of establishing the level of influence, relationship and if the objective was the cause or effect of another. See Table 8.

Once the steps of the fuzzy DEMATEL were completed, the optimization model was implemented, which seeks to minimize the number of relationships between strategic objectives and to eliminate the objectives with lower score by the experts. The optimization model showed the relationships between objectives and the resulting objectives. The result can be translated graphically into a strategy map that shows the classification of the objectives in each

perspective of the BSC and the resulting relationships between each one of them, which allows the organization to visualize the most relevant and influential objectives for the strategy.

In order to test the robustness of the solutions, as shown in Table 9, the optimization model was evaluated by the variation of the proposed levels in the parameters α (i.e., the minimum percentage of total relations between desired objectives in the strategy map); β (i.e., the minimum percentage of relations between objectives of contiguous perspectives); and γ (i.e., the minimum percentage of total score of the strategic objectives that will establish how many of those with higher scores will be included in the strategy map). These tests were performed with the input parameters of the scores provided by the experts to the strategic objectives. It is worth mentioning that the contiguous perspectives are learning and growth and internal processes, internal processes and clients and, finally, clients and financial.

One hundred twenty-five tests were performed according to the possible combinations of the parameters, in which the number of resulting relationships, number of resulting objectives, and the feasibility of the solution were evaluated. In Table 10, the results are shown when $\beta = 0.2$ and the other parameters are varied.

With an $\alpha = 0.9$ the solutions were not feasible given that this value causes restriction No. 1 to be so strong that it does not allow the optimization model to find solutions. On the other hand, it was evident that at a constant β level, the results of the number of relationships vary according to the

Table 3 List of strategic objectives

N°	Strategic area	Objective definition
A1	Research projects	Increase the number of research projects
A2	Innovation in teaching and learning	Train teachers in teaching and learning processes to generate constant growth
A3	Academic publications	Promote research publications with the aim of increasing the international profile
A4	Faculty development	Promote faculty development policies
A5	IT infrastructure	Develop physical and virtual environments that foster cohesion and excellence for staff, students and collaborators
P1	Quality in colleges	Obtain certificates and accreditations that prove the quality of academic programs, research centers, laboratories, etc
P2	Quality in the teaching processes	Create effective management of teaching which allows providing an excellent education
P3	Quality in administrative processes for students	Improve the effectiveness of services provided at the university
P4	Quality in administrative processes for employees	Improve the effectiveness of services provided at the university
P5	Quality in the curriculum	Update the curriculum according to educational, business and commercial trends
P6	Cooperation between the university and the business community	Establish relationships with industry that allow students to approach the professional field
P7	Cooperation between the university and other educational institutions	Establish relations with other national and international universities that allow students to carry out exchanges
P8	Adaptation of the campus	Provide students with adequate spaces for the realization of their academic activities
C1	Student satisfaction	Provide services to students who meet their academic needs
C2	Expansion of new students	Increase the number of students enrolled
C3	Graduate students	Graduate professionals with high quality that adapt to the demands of society
C4	Brand	Position the university with the highest reputation
C5	Student welfare	Provide students with adequate spaces for carrying out their activities
F1	Control of costs	Reduce direct and indirect costs associated with the provision of faculty services
F2	Resource management	Allocate resources effectively to teaching, research and consulting processes
F3	Fundraising	Raise funds needed to carry out the teaching, research, and consulting activities of the colleges
F4	Increase in profitability	Increase revenues from services rendered

level of the α , without influencing the level γ , since this directly affects the elimination of strategic objectives.

A descriptive analysis was developed with the results of the 100 feasible results in order to know the deviation, the average and the coefficient of variation of the data. The results are found in Table 11.

Based on these results, it is highlighted that the model presented a heterogeneity evidenced by the value of the coefficient of variation of 43.83% in the results for the number of relations resulting from the different scenarios of the model. Additionally, it is possible to determine a minimization of the relationships between strategic objectives, since on average; approximately 102 relationships of 285 possible were obtained. On the other hand, the number of resulting objectives had a lower coefficient of variation, because the results of the proposed scenarios tended to be homogeneous.

Next, the number of relationships resulting from 100 of the 125 performance tests was presented graphically, given

that the remaining 25 correspond to not feasible solutions for $\alpha = 0.9$. Figure 2 shows the number of relationships for different levels α for a certain level of β , and the former is replicated for the different proposed values of β . Additionally, it was observed that as α and β were higher, a greater relationships between the strategic objectives were obtained.

For the 100 feasible performance tests, it was found that the higher α and β , the lower the level of influence the parameter γ , making the number of resulting targets more homogeneous throughout the different configurations of parameters, as shown in Fig. 3.

Based on the above information, it was noticed that the results of the performance tests met the expected performance requirements because the number of causal relationships between the strategic objectives is minimized, a reduction percentage of the number of objectives initially set and strategic objectives are prioritized according to the information given by the experts.

Table 4 Initial matrix of one expert with linguistic values

<i>i/i</i>	A1	A2	A3	A4	A5	P1	P2	P3	P4	P5	P6	P7	P8	C1	C2	C3	C4	C5	F1	F2	F3	F4
A1		VL	VH	L	VH	H	VL	N	H	L	VH	H	L	L	L	L	VH	N	N	L	H	H
A2	VL		N	H	H	VH	VH	H	H	VH	L	L	L	VH	H	VH	VH	VH	N	VL	VL	VL
A3	VH	N		L	H	VH	VL	N	H	L	H	H	L	L	L	L	VH	N	N	L	VL	L
A4	L	H	L		H	VH	VH	H	H	VH	L	H	L	VH	H	VH	VH	VH	N	VL	VL	VL
A5	VH	H	H	H		VH	H	VH	H	VH	N	N	VH	VH	VH	VL	VH	VH	VH	VH	VH	VH
P1							VH	VH	H	VH	L	H	VH	VH	VH	VH	VH	VH	L	VH	VH	VH
P2						VH		L	H	VH	L	H	VH	VH	VH	VH	VH	VH	H	H	H	VH
P3						VH	L		L	H	L	H	VH	VH	H	VH	VH	VH	H	H	L	L
P4						H	H	L		N	H	H	L	VL	L	VL	H	VL	H	H	H	H
P5						VH	VH	H	N		H	H	VL	VH	VH	VH	VH	VH	VL	H	VH	VH
P6						L	L	L	H	H		H	VH	L	H	L	VH	L	H	H	VH	VH
P7						H	H	H	H	H	H		VH	VH	VH	H	VH	H	VH	VH	VH	VH
P8						VH	VH	VH	L	VL	VH	VH		VH	VH	VH	VH	VH	VH	VH	VH	VH
C1															VH	VH	VH	VH	H	H	H	H
C2														VH		VH	VH	VH	H	H	VH	VH
C3														VH	VH		VH	VH	H	VL	VL	VL
C4														VH	VH	VH		VH	H	H	VH	VH
C5														VH	VH	VH	VH		H	H	H	H
F1																				H	VL	VH
F2																				H		VH
F3																				VL	L	VH
F4																				VH	VH	VH

Additionally, the similarity indicator described in López-Ospina et al. (2017) was calculated for the 100 feasible tests. Table 12 shows the results of this indicator for the 100 feasible performance tests, based on the strategy map with parameters $\beta = 0.2$; $\alpha = 0.2$; and $\gamma = 0.2$.

Giving the stated above, it was reported how the strategy maps vary with respect to the base situation and this indicates the importance of the correct assignment of the values of these parameters with respect to the strategy proposed for a higher education institution.

In order to compare and analyze the number of resulting relationships, a more disaggregated analysis of four possible scenarios varying the parameters α ; β ; γ ; T_i ; S_j was performed. The number of resulting objectives, the percentage of reduction of relationships and the percentage of reduction of objectives are presented in Table 13. The parameters for each of the resulting cases were selected after doing several tests described in Table 8.

For case 1 and case 2, the objectives of the learning and growth perspective should not be the effect of other objectives; and those that belong to the financial perspective should not be the cause of the other objectives. On the other hand, for case 3 and case 4, financial objectives are allowed to influence others of the same perspective;

similarly for learning and growth objectives. Cases 1–4 with their corresponding figures are presented as follows:

Some examples of the relationships obtained in the strategy map of Fig. 4 show that by generating innovation processes in teaching and learning a positive impact is generated in the quality of the curriculum, which generates well-being in the students and, therefore, an increase of the educational institution profitability. On the other hand, it is possible to consider that the research projects generate an impact on the quality of the colleges and this, in turn, influences the brand and the collection of funds. Likewise, it can be observed that by improving the IT infrastructure student’s well-being is changed since the computer infrastructure allows the development of physical and virtual environments that foster student’s performance (Hashemkhani Zolfani and Safaei Ghadikolaei 2012). This objective also influences the institution’s profitability.

The map in Fig. 4 contains 41 relationships, corresponding to 14.4% of the total of possible relationships; this means that the proposed model considers that 85.6% of the relationships are not truly relevant. This allows to place more efficiently resources and efforts that facilitate fulfilling the strategy of the organization. Additionally, it was found that 90.24% of map relationships came from the

Table 5 Minimum matrix (λ) for the expert

<i>i/j</i>	A1	A2	A3	A4	A5	P1	P2	P3	P4	P5	P6	P7	P8	C1	C2	C3	C4	C5	F1	F2	F3	F4
A1		0	0.75	0.25	0.75	0.5	0	0	0.5	0.25	0.75	0.5	0.25	0.25	0.25	0.25	0.75	0	0	0.25	0.5	0.5
A2	0		0	0.5	0.5	0.75	0.75	0.5	0.5	0.75	0.25	0.25	0.25	0.75	0.5	0.75	0.75	0.75	0	0	0	0
A3	0.75	0		0.25	0.5	0.75	0	0	0.5	0.25	0.5	0.5	0.25	0.25	0.25	0.25	0.75	0	0	0.25	0	0.25
A4	0.25	0.5	0.25		0.5	0.75	0.75	0.5	0.5	0.75	0.25	0.5	0.25	0.75	0.5	0.75	0.75	0.75	0	0	0	0
A5	0.75	0.5	0.5	0.5		0.75	0.5	0.75	0.5	0.75	0	0	0.75	0.75	0.75	0	0.75	0.75	0.75	0.75	0.75	0.75
P1							0.75	0.75	0.5	0.75	0.25	0.5	0.75	0.75	0.75	0.75	0.75	0.75	0.25	0.25	0.75	0.75
P2						0.75		0.25	0.5	0.75	0.25	0.5	0.75	0.75	0.75	0.75	0.75	0.75	0.5	0.5	0.5	0.75
P3						0.75	0.25		0.25	0.5	0.25	0.5	0.75	0.75	0.5	0.75	0.75	0.75	0.5	0.5	0.5	0.25
P4						0.5	0.5	0.25		0	0.5	0.5	0.25	0	0.25	0	0.5	0	0.5	0.5	0.5	0.5
P5						0.75	0.75	0.5	0	0.5	0.5	0.5	0	0.75	0.75	0.75	0.75	0.75	0	0.5	0.75	0.75
P6						0.25	0.25	0.25	0.5	0.5		0.5	0.75	0.25	0.5	0.25	0.75	0.25	0.5	0.5	0.5	0.75
P7						0.5	0.5	0.5	0.5	0.5	0.5		0.75	0.75	0.75	0.5	0.75	0.5	0.75	0.75	0.75	0.75
P8						0.75	0.75	0.75	0.25	0	0.75	0.75		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
C1															0.75	0.75	0.75	0.75	0.5	0.5	0.5	0.5
C2														0.75		0.75	0.75	0.75	0.5	0.5	0.75	0.75
C3														0.75	0.75		0.75	0.75	0.5	0	0	0
C4														0.75	0.75	0.75		0.75	0.5	0.5	0.75	0.75
C5														0.75	0.75	0.75	0.75		0.5	0.5	0.5	0.5
F1																				0.5	0	0.75
F2																			0.5		0.25	0.75
F3																			0	0.25		0.75
F4																			0.75	0.75	0.75	0.75

Table 6 Minimum matrix average (step 4 of revisited fuzzy DEMATEL)

<i>i/j</i>	A1	A2	A3	A4	A5	P1	P2	P3	P4	P5	P6	P7	P8	C1	C2	C3	C4	C5	F1	F2	F3	F4
A1	0.00	0.38	0.67	0.54	0.38	0.58	0.25	0.13	0.21	0.38	0.46	0.46	0.17	0.17	0.25	0.25	0.58	0.13	0.13	0.33	0.46	0.38
A2	0.25	0.00	0.21	0.54	0.50	0.63	0.71	0.29	0.29	0.71	0.25	0.33	0.46	0.63	0.54	0.50	0.58	0.63	0.25	0.29	0.33	0.38
A3	0.58	0.21	0.00	0.54	0.38	0.58	0.25	0.13	0.21	0.38	0.42	0.54	0.25	0.25	0.25	0.29	0.58	0.13	0.13	0.25	0.33	0.38
A4	0.38	0.46	0.50	0.00	0.33	0.63	0.63	0.25	0.21	0.63	0.42	0.46	0.29	0.54	0.38	0.42	0.58	0.54	0.29	0.29	0.29	0.29
A5	0.38	0.46	0.25	0.29	0.00	0.54	0.54	0.67	0.63	0.46	0.17	0.13	0.63	0.71	0.42	0.21	0.42	0.54	0.54	0.67	0.42	0.46
P1	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.54	0.50	0.67	0.38	0.50	0.50	0.63	0.50	0.46	0.54	0.58	0.29	0.46	0.46	0.42
P2	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.33	0.38	0.71	0.33	0.38	0.46	0.63	0.58	0.46	0.54	0.63	0.38	0.42	0.38	0.42
P3	0.00	0.00	0.00	0.00	0.00	0.71	0.38	0.00	0.38	0.29	0.21	0.29	0.42	0.54	0.29	0.33	0.38	0.58	0.46	0.46	0.25	0.33
P4	0.00	0.00	0.00	0.00	0.00	0.38	0.38	0.29	0.00	0.21	0.25	0.21	0.33	0.21	0.21	0.13	0.25	0.21	0.50	0.50	0.38	0.33
P5	0.00	0.00	0.00	0.00	0.00	0.71	0.71	0.38	0.25	0.00	0.42	0.46	0.29	0.54	0.46	0.46	0.50	0.63	0.25	0.29	0.33	0.33
P6	0.00	0.00	0.00	0.00	0.00	0.38	0.25	0.21	0.25	0.42	0.00	0.33	0.38	0.29	0.33	0.33	0.50	0.25	0.33	0.42	0.63	0.54
P7	0.00	0.00	0.00	0.00	0.00	0.50	0.42	0.29	0.21	0.42	0.38	0.00	0.38	0.46	0.46	0.42	0.50	0.38	0.29	0.33	0.46	0.33
P8	0.00	0.00	0.00	0.00	0.00	0.50	0.46	0.46	0.38	0.33	0.38	0.33	0.00	0.63	0.50	0.46	0.63	0.71	0.50	0.54	0.58	0.54
C1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.54	0.63	0.67	0.33	0.42	0.38	0.38
C2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.42	0.46	0.46	0.33	0.38	0.54	0.58
C3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.54	0.00	0.54	0.46	0.29	0.21	0.33	0.29
C4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.58	0.50	0.00	0.50	0.29	0.33	0.50	0.50
C5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.58	0.50	0.58	0.00	0.38	0.38	0.38	0.42
F1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.38	0.67
F2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.46	0.63
F3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.50	0.00	0.71
F4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.67	0.67	0.00

Table 7 Total relationships minimum matrix

<i>i/j</i>	A1	A2	A3	A4	A5	P1	P2	P3	P4	P5	P6	P7	P8	C1	C2	C3	C4	C5	F1	F2	F3	F4
A1	0.01	0.05	0.08	0.07	0.05	0.10	0.06	0.04	0.05	0.08	0.07	0.08	0.05	0.08	0.08	0.08	0.12	0.07	0.07	0.10	0.12	0.11
A2	0.03	0.01	0.03	0.06	0.06	0.11	0.11	0.06	0.06	0.11	0.06	0.07	0.08	0.14	0.13	0.12	0.14	0.14	0.10	0.11	0.12	0.13
A3	0.07	0.03	0.01	0.07	0.05	0.10	0.06	0.04	0.05	0.07	0.07	0.08	0.05	0.09	0.08	0.08	0.12	0.07	0.07	0.09	0.10	0.11
A4	0.05	0.05	0.06	0.01	0.04	0.11	0.10	0.06	0.05	0.10	0.07	0.08	0.06	0.13	0.11	0.10	0.13	0.13	0.10	0.11	0.11	0.12
A5	0.05	0.05	0.03	0.04	0.01	0.10	0.10	0.10	0.09	0.09	0.05	0.04	0.10	0.14	0.11	0.08	0.11	0.13	0.13	0.15	0.13	0.14
P1	0.00	0.00	0.00	0.00	0.00	0.03	0.10	0.08	0.07	0.09	0.06	0.07	0.07	0.12	0.11	0.10	0.11	0.12	0.09	0.11	0.12	0.12
P2	0.00	0.00	0.00	0.00	0.00	0.10	0.03	0.05	0.06	0.09	0.05	0.06	0.07	0.12	0.11	0.09	0.11	0.12	0.10	0.11	0.10	0.11
P3	0.00	0.00	0.00	0.00	0.00	0.09	0.06	0.02	0.05	0.05	0.04	0.05	0.06	0.10	0.07	0.07	0.08	0.10	0.10	0.10	0.08	0.09
P4	0.00	0.00	0.00	0.00	0.00	0.06	0.05	0.04	0.01	0.04	0.04	0.03	0.05	0.05	0.05	0.04	0.05	0.05	0.09	0.09	0.08	0.08
P5	0.00	0.00	0.00	0.00	0.00	0.10	0.09	0.06	0.04	0.02	0.06	0.07	0.05	0.11	0.10	0.09	0.10	0.11	0.08	0.09	0.10	0.10
P6	0.00	0.00	0.00	0.00	0.00	0.06	0.04	0.03	0.04	0.06	0.01	0.05	0.05	0.07	0.07	0.06	0.09	0.06	0.08	0.09	0.11	0.11
P7	0.00	0.00	0.00	0.00	0.00	0.07	0.06	0.05	0.04	0.06	0.05	0.02	0.05	0.09	0.09	0.08	0.09	0.08	0.08	0.09	0.10	0.09
P8	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.06	0.05	0.05	0.05	0.05	0.02	0.11	0.10	0.09	0.11	0.12	0.11	0.12	0.12	0.12
C1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.08	0.07	0.08	0.08	0.06	0.07	0.07	0.07
C2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.02	0.06	0.06	0.06	0.06	0.06	0.08	0.09
C3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.07	0.01	0.07	0.06	0.05	0.04	0.06	0.06
C4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.06	0.02	0.07	0.05	0.06	0.08	0.08
C5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.07	0.08	0.02	0.06	0.06	0.07	0.07
F1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	0.05	0.08
F2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.06	0.08
F3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.06	0.01	0.08
F4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.02

	A1	A2	A3	A4	A5	P1	P2	P3	P4	P5	P6	P7	P8	C1	C2	C3	C4	C5	F1	F2	F3	F4
A1	0.00	0.05	0.07	0.06	0.05	0.10	0.07	0.05	0.05	0.08	0.08	0.08	0.06	0.09	0.09	0.09	0.12	0.08	0.09	0.11	0.12	0.12
A2	0.04	0.00	0.04	0.06	0.06	0.10	0.10	0.07	0.06	0.10	0.06	0.07	0.08	0.13	0.12	0.12	0.13	0.13	0.11	0.12	0.12	0.13
A3	0.06	0.03	0.00	0.06	0.05	0.10	0.07	0.05	0.05	0.08	0.07	0.08	0.06	0.09	0.09	0.09	0.12	0.08	0.09	0.10	0.11	0.12
A4	0.05	0.05	0.06	0.00	0.04	0.10	0.10	0.06	0.05	0.10	0.08	0.08	0.07	0.13	0.11	0.11	0.13	0.12	0.11	0.12	0.12	0.12
A5	0.05	0.05	0.04	0.04	0.00	0.10	0.09	0.09	0.09	0.09	0.06	0.06	0.09	0.13	0.11	0.09	0.11	0.12	0.13	0.15	0.13	0.14
P1	0	0	0	0	0	0.00	0.09	0.07	0.07	0.08	0.06	0.07	0.07	0.11	0.10	0.09	0.10	0.11	0.10	0.11	0.11	0.11
P2	0	0	0	0	0	0.09	0.00	0.05	0.06	0.08	0.06	0.06	0.06	0.11	0.10	0.09	0.10	0.11	0.10	0.11	0.10	0.11
P3	0	0	0	0	0	0.08	0.06	0.00	0.06	0.05	0.04	0.05	0.06	0.10	0.08	0.08	0.08	0.10	0.10	0.10	0.09	0.10
P4	0	0	0	0	0	0.06	0.06	0.05	0.00	0.04	0.04	0.04	0.05	0.06	0.06	0.05	0.06	0.06	0.09	0.10	0.09	0.09
P5	0	0	0	0	0	0.09	0.08	0.06	0.04	0.00	0.06	0.06	0.06	0.10	0.09	0.09	0.10	0.11	0.09	0.09	0.10	0.10
P6	0	0	0	0	0	0.06	0.05	0.04	0.04	0.06	0.00	0.05	0.06	0.07	0.08	0.07	0.09	0.07	0.09	0.10	0.11	0.11
P7	0	0	0	0	0	0.07	0.06	0.05	0.04	0.06	0.06	0.00	0.06	0.09	0.09	0.08	0.09	0.09	0.09	0.09	0.10	0.10
P8	0	0	0	0	0	0.07	0.07	0.06	0.06	0.06	0.06	0.05	0.00	0.10	0.10	0.09	0.10	0.11	0.11	0.11	0.12	0.12
C1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.07	0.07	0.07	0.07	0.06	0.07	0.07	0.07
C2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	0.00	0.06	0.06	0.06	0.06	0.07	0.08	0.08
C3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	0.07	0.00	0.07	0.06	0.06	0.05	0.06	0.06
C4	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	0.07	0.06	0.00	0.06	0.06	0.06	0.07	0.08
C5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0.07	0.06	0.07	0.00	0.06	0.07	0.07	0.07
F1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.07	0.05	0.07
F2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	0.00	0.06	0.07
F3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0.06	0.00	0.07
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	0.07	0.07	0.01

Fig. 1 Matrix of total relationships

Table 8 Causality analysis

Estrategic objectives	D (level of influence)	R (level of relationship)	D + R (importance level)	D - R	Cause or effect
A1	1.71	0.23	1.94	1.49	Cause
A2	1.95	0.22	2.17	1.73	Cause
A3	1.71	0.21	1.91	1.50	Cause
A4	1.92	0.23	2.15	1.69	Cause
A5	1.98	0.22	2.20	1.76	Cause
P1	1.49	1.03	2.52	0.46	Cause
P2	1.43	0.94	2.37	0.50	Cause
P3	1.25	0.77	2.03	0.48	Cause
P4	1.09	0.74	1.83	0.34	Cause
P5	1.36	0.93	2.29	0.43	Cause
P6	1.20	0.78	1.99	0.42	Cause
P7	1.30	0.83	2.13	0.47	Cause
P8	1.43	0.86	2.29	0.57	Cause
C1	0.55	1.51	2.06	- 0.97	Effect
C2	0.50	1.45	1.95	- 0.95	Effect
C3	0.47	1.34	1.81	- 0.87	Effect
C4	0.50	1.54	2.05	- 1.04	Effect
C5	0.55	1.48	2.03	- 0.93	Effect
F1	0.19	1.87	2.06	- 1.68	Effect
F2	0.19	2.00	2.19	- 1.81	Effect
F3	0.19	2.00	2.19	- 1.80	Effect
F4	0.21	2.02	2.23	- 1.81	Effect

learning and growth and internal processes perspectives. It is highlighted that through the fulfillment of the objectives of the perspectives mentioned above; the objectives of the financial aspect can be reached. This seem to

emphasize the need of organizations of focusing their actions on critical aspects such as the financial perspective.

Note that in strategy maps of Fig. 4 a 5 the parameters S_j (i.e., consequence of other strategic objective) and T_i (i.e.,

Table 9 Variation of performance test parameters

Parameters	β_1		β_2		β_3		β_4		β_5	
	0.2	0.3	0.2	0.3	0.5	0.7	0.7	0.9	0.9	
α_1										
0.2	γ_1	0.2	γ_1	0.2	γ_1	0.2	γ_1	0.2	γ_1	0.2
	γ_2	0.3	γ_2	0.3	γ_2	0.3	γ_2	0.3	γ_2	0.3
	γ_3	0.5	γ_3	0.5	γ_3	0.5	γ_3	0.5	γ_3	0.5
	γ_4	0.7	γ_4	0.7	γ_4	0.7	γ_4	0.7	γ_4	0.7
	γ_5	0.9	γ_5	0.9	γ_5	0.9	γ_5	0.9	γ_5	0.9
α_2										
0.3	γ_1	0.2	γ_1	0.2	γ_1	0.2	γ_1	0.2	γ_1	0.2
	γ_2	0.3	γ_2	0.3	γ_2	0.3	γ_2	0.3	γ_2	0.3
	γ_3	0.5	γ_3	0.5	γ_3	0.5	γ_3	0.5	γ_3	0.5
	γ_4	0.7	γ_4	0.7	γ_4	0.7	γ_4	0.7	γ_4	0.7
	γ_5	0.9	γ_5	0.9	γ_5	0.9	γ_5	0.9	γ_5	0.9
α_3										
0.5	γ_1	0.2	γ_1	0.2	γ_1	0.2	γ_1	0.2	γ_1	0.2
	γ_2	0.3	γ_2	0.3	γ_2	0.3	γ_2	0.3	γ_2	0.3
	γ_3	0.5	γ_3	0.5	γ_3	0.5	γ_3	0.5	γ_3	0.5
	γ_4	0.7	γ_4	0.7	γ_4	0.7	γ_4	0.7	γ_4	0.7
	γ_5	0.9	γ_5	0.9	γ_5	0.9	γ_5	0.9	γ_5	0.9
α_4										
0.7	γ_1	0.2	γ_1	0.2	γ_1	0.2	γ_1	0.2	γ_1	0.2
	γ_2	0.3	γ_2	0.3	γ_2	0.3	γ_2	0.3	γ_2	0.3
	γ_3	0.5	γ_3	0.5	γ_3	0.5	γ_3	0.5	γ_3	0.5
	γ_4	0.7	γ_4	0.7	γ_4	0.7	γ_4	0.7	γ_4	0.7
	γ_5	0.9	γ_5	0.9	γ_5	0.9	γ_5	0.9	γ_5	0.9
α_5										
0.9	γ_1	0.2	γ_1	0.2	γ_1	0.2	γ_1	0.2	γ_1	0.2
	γ_2	0.3	γ_2	0.3	γ_2	0.3	γ_2	0.3	γ_2	0.3
	γ_3	0.5	γ_3	0.5	γ_3	0.5	γ_3	0.5	γ_3	0.5
	γ_4	0.7	γ_4	0.7	γ_4	0.7	γ_4	0.7	γ_4	0.7
	γ_5	0.9	γ_5	0.9	γ_5	0.9	γ_5	0.9	γ_5	0.9

cause of other strategic objective) were not modified. Consequently, in these scenarios the objectives that belong to the financial perspective should not be the cause of the realization of other objectives; and those of the perspective of learning and growth, should not be the effect of others. However, for the strategy maps of Figs. 6 and 7 these parameters were modified so that all the objectives could be the cause and effect of others, in other words, the financial objectives were allowed to influence others from their same perspective; as well as the learning and growth objectives.

In the strategy map of Fig. 5, some examples of the relationships are presented in which improvements in faculty development and innovation in the learning and

teaching processes impacted the quality of the colleges and this, in turn, produced improvements in student satisfaction, increasing profitability.

The map in Fig. 5 contains 20 relationships, which corresponded to 7.02% of the total of possible relationships. Thus, the proposed model considers that 92.98% of the relationships are not very relevant. Besides, it is relevant to mention that there is a 45.45% reduction in the strategic objectives, which resulted in the elimination of 10 of the 22 initial objectives. Additionally, it was found that 90% of map relationships come from the perspectives of learning and growth and internal processes.

On the other hand, Fig. 6 shows that the variation in the cause-effect relationship of each of the strategic objectives creates relationships between objectives of the same perspective (i.e., financial and learning and growth). This will depend on the goals set out for each organization. Despite that when analyzing an example of the relationships between objectives it is noticeable that the objective of innovation in teaching and learning influences the quality of the teaching processes and generates satisfaction in the students and this, in turn, causes an increase in the profitability of the higher education institution.

For this map, 50% of the strategic objectives were eliminated, and 23 relationships between these objectives were obtained. Also, the perspective of learning and growth and internal processes represent 78.26% of the final total relationships, which suggest that the organization need to align efforts from these perspectives.

Finally, in Fig. 7, the map shows, for example, that the strategic objective of the IT infrastructure of the learning and growth perspective influences the goal of adaption of the campus. This adaptation generates well-being in the student and therefore increases the profitability of the higher education institution. Additionally, it is found that the relations between strategic objectives of the same perspective (i.e., financial and learning and growth), which indicates that the methodology allows analyzing different options according to different needs of decision makers.

In this last map, 36.36% of the strategic objectives were eliminated, and there were 44 relationships between these objectives. In addition, it is observed that like the other three maps presented previously, the perspectives of learning and growth and internal processes represent 84% of the final total relationships, which indicates that organizations should pay special attention to these perspectives, since the objectives that compose them have a considerable amount of effects in other objectives.

In the previous figures, it was possible to observe that for each of the perspectives there must always be at least one strategic objective and that the relations between them must be ascending. It is also emphasized that the parameters of the model (i.e., α , β , and γ) should be clearly

Table 10 Results analysis when $\beta = 0.2$

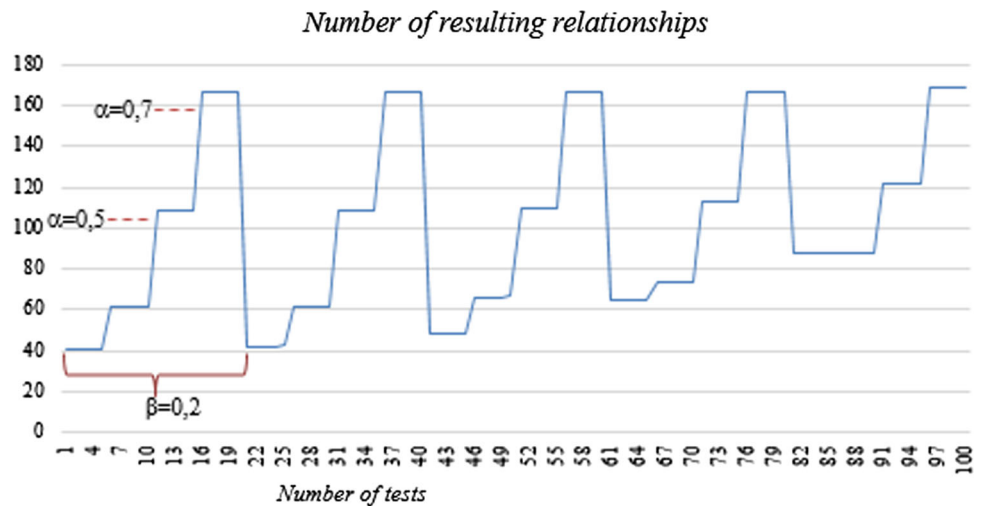
$\beta = 0.2$	Number of relationships	Number of resulting objectives	% of target reduction	Feasibility
$\alpha = 0.2; \gamma = 0.2$	41	16	27.27	Feasible
$\alpha = 0.2; \gamma = 0.3$	41	16	27.27	Feasible
$\alpha = 0.2; \gamma = 0.5$	41	16	27.27	Feasible
$\alpha = 0.2; \gamma = 0.7$	41	16	27.27	Feasible
$\alpha = 0.2; \gamma = 0.9$	41	20	9.09	Feasible
$\alpha = 0.3; \gamma = 0.2$	61	17	22.73	Feasible
$\alpha = 0.3; \gamma = 0.3$	61	17	22.73	Feasible
$\alpha = 0.3; \gamma = 0.5$	61	17	22.73	Feasible
$\alpha = 0.3; \gamma = 0.7$	61	17	22.73	Feasible
$\alpha = 0.3; \gamma = 0.9$	61	20	9.09	Feasible
$\alpha = 0.5; \gamma = 0.2$	109	22	0.00	Feasible
$\alpha = 0.5; \gamma = 0.3$	109	22	0.00	Feasible
$\alpha = 0.5; \gamma = 0.5$	109	22	0.00	Feasible
$\alpha = 0.5; \gamma = 0.7$	109	22	0.00	Feasible
$\alpha = 0.5; \gamma = 0.9$	109	22	0.00	Feasible
$\alpha = 0.7; \gamma = 0.2$	167	22	0.00	Feasible
$\alpha = 0.7; \gamma = 0.3$	167	22	0.00	Feasible
$\alpha = 0.7; \gamma = 0.5$	167	22	0.00	Feasible
$\alpha = 0.7; \gamma = 0.7$	167	22	0.00	Feasible
$\alpha = 0.7; \gamma = 0.9$	167	22	0.00	Feasible

Test results with $\beta = 0.2$; varying the other parameters

Table 11 Analysis of total results

Number of relations			Number of resulting objectives		
Deviation	Average	Coefficient of variation	Deviation	Average	Coefficient of variation
44.60	101.77	43.83%	2.03	20.72	9.80%

Fig. 2 Number of resulting relationships



established since a variation in them generates different results that can cause changes in the decision making. This

may lead to a poor adaptation to the organization's strategy.

Fig. 3 Number of resulting strategic objectives



Table 12 Results of similarity indicator

Similarity indicator					
Variation	$\beta = 0.2$	$\beta = 0.3$	$\beta = 0.5$	$\beta = 0.7$	$\beta = 0.9$
$\alpha = 0.2; \gamma = 0.2$	100.0%	85.3%	83.5%	75.4%	67.4%
$\alpha = 0.2; \gamma = 0.3$	98.6%	85.3%	83.5%	75.4%	67.4%
$\alpha = 0.2; \gamma = 0.5$	98.6%	93.3%	83.5%	75.4%	67.4%
$\alpha = 0.2; \gamma = 0.7$	93.7%	93.3%	83.5%	75.4%	66.0%
$\alpha = 0.2; \gamma = 0.9$	95.1%	92.3%	83.5%	75.4%	67.4%
$\alpha = 0.3; \gamma = 0.2$	92.3%	91.9%	89.8%	78.6%	67.4%
$\alpha = 0.3; \gamma = 0.3$	92.3%	91.9%	89.8%	78.6%	67.4%
$\alpha = 0.3; \gamma = 0.5$	92.3%	91.9%	89.8%	78.6%	67.4%
$\alpha = 0.3; \gamma = 0.7$	92.3%	92.6%	89.8%	74.0%	66.0%
$\alpha = 0.3; \gamma = 0.9$	90.2%	92.6%	89.5%	78.6%	67.4%
$\alpha = 0.5; \gamma = 0.2$	74.7%	90.5%	75.8%	74.7%	71.6%
$\alpha = 0.5; \gamma = 0.3$	74.7%	74.7%	75.8%	74.7%	71.6%
$\alpha = 0.5; \gamma = 0.5$	74.7%	74.7%	75.8%	74.7%	71.6%
$\alpha = 0.5; \gamma = 0.7$	74.7%	75.4%	75.8%	74.7%	71.6%
$\alpha = 0.5; \gamma = 0.9$	74.7%	75.4%	75.8%	74.7%	71.6%
$\alpha = 0.7; \gamma = 0.2$	55.8%	55.8%	55.8%	55.8%	55.1%
$\alpha = 0.7; \gamma = 0.3$	55.8%	55.8%	55.8%	55.8%	55.1%
$\alpha = 0.7; \gamma = 0.5$	55.8%	55.8%	55.8%	55.8%	55.1%
$\alpha = 0.7; \gamma = 0.7$	55.8%	55.8%	55.8%	55.8%	55.1%
$\alpha = 0.7; \gamma = 0.9$	55.8%	55.8%	55.8%	55.8%	55.1%

On the other hand, the effect of the results obtained was measured through the indicators of percentage of reduction of objectives, reduction of relations and percentage of importance. The last indicator was taken from the work of López-Ospina et al. (2017). In Table 14, the result of the combinations of the parameters that were used to construct the maps are presented:

It is highlighted that for the four scenarios presented (case 1–4), there was an elimination of objectives of at

least 27.27 and 85.61% of reduction of relations between these strategic objectives, which indicates that the model significantly reduced the relations since its objective function aims to minimize them, prioritizing the most important ones according to the qualification given by the experts. It is possible to observe that the proposed methodology suggests that objectives are the most influential in achieving the organization’s strategy, reducing the subjectivity in the choice of these, according to the variation of the parameters. For example, for a decision maker in a higher education institution the most important thing may be the brand (reputation), and in two of the four cases raised, this goal is eliminated giving priority to others such as teacher development, student satisfaction, among others. For the four cases remain the objectives of innovation in teaching and learning, teacher development, a computer infrastructure, quality in the colleges, quality in teaching processes, student satisfaction, student welfare, resource management, collection of funds and increased profitability.

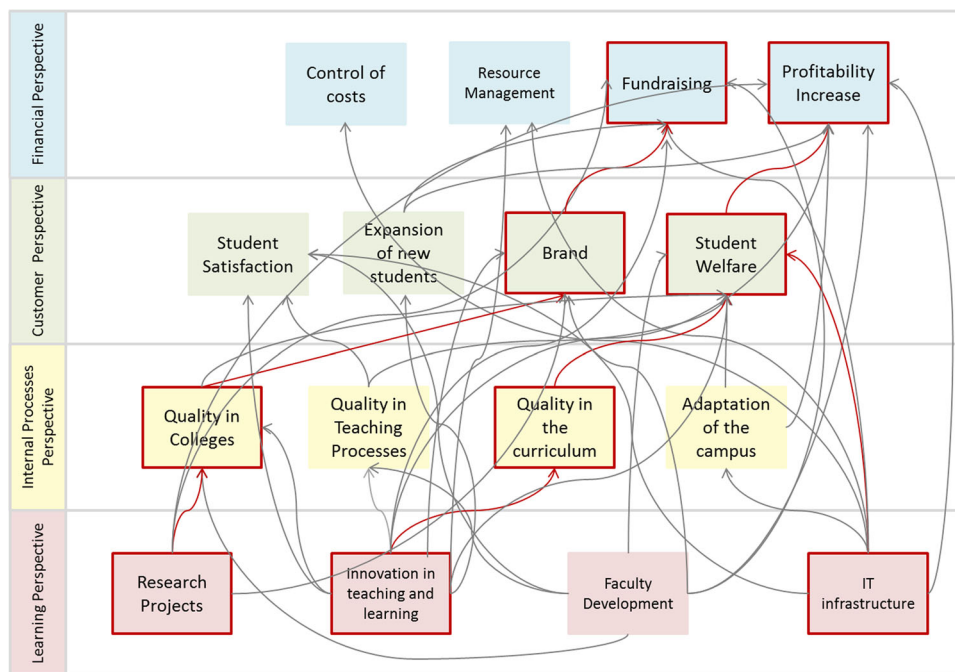
Then, the resulting objectives are presented in Table 15 and which were eliminated according to the variation of parameters. It can be evidenced that depending on the established parameters, different objectives are eliminated and the relationships between them change, causing the decision making to be different.

According to Table 15, for these four cases, regardless of the variation of the parameters, the objectives of innovation in teaching and learning; faculty development; IT infrastructure; quality in the colleges; quality in the teaching processes; student satisfaction; student welfare; management of resources; fundraising; and increase profitability, remained constant. Therefore, this makes higher education institutions question the importance of allocating efforts and resources for the fulfillment of these objectives, especially those that belong to the perspective of learning

Table 13 Parameters of resulting strategy maps

Parameter	Case 1	Case 2	Case 3	Case 4
Figure	4	5	6	7
Value α	0.2	0.1	0.1	0.2
Value β	0.2	0.1	0.1	0.2
Value γ	0.2	0.1	0.1	0.2
S_j (effect of another strategic objective)	$1 \forall j \in P; C; F$	$1 \forall j \in P; C; F$	$1 \forall j$	$1 \forall j$
T_i (cause of another strategic objective)	$1 \forall i \in A; P; C$	$1 \forall i \in A; P; C$	$1 \forall i$	$1 \forall i$

Fig. 4 Resulting strategy map $\alpha = 0.2; \beta = 0.2; \gamma = 0.2$ (Case 1, Table 13)



and growth, since these are a cause and directly influence the objectives of the other perspectives.

Figure 8 is a flowchart that synthesizes the different processes carried out in this section to obtain the strategy map of an organization.

5 Conclusions and recommendations

This work proposes a method that integrates fuzzy DEMATEL and optimization, for construction of strategy maps allowing the selection of the most relevant objectives and relationships for the organization. To illustrate the method, an application in the higher education sector is presented along with the explanation of the method. In doing so, the strategic objectives were established based on the literature and the causal relationships between the objectives of the four perspectives of the BSC and the most important objectives for the strategy were prioritized. This was achieved by the application of the fuzzy DEMATEL

method that determined the causal relationships and the effects of the variables of the strategy map; and a linear programming optimization model that allows to minimize the causal relationships and to eliminate the objectives (based on the usefulness, understandability and feasibility) that had the lowest scores from the experts' judgment. This helps the understanding of the strategic structure of the organization and the efforts and necessary resources to achieve the relevant objectives.

Regarding particularly about the practical example that was used to assess the performance of the method, several conclusions can be observed. First, a series of tests were performed, varying the parameters of the optimization model that showed the feasibility of the solutions, except for those obtained with a value of $\alpha = 0.9$, which restricted the model in such a way that viable solutions were not found. These findings demonstrated the importance of the parameters variation to find multiple solutions that adapts to different organizational needs according to specific strategic decision making. For this reason, it is essential to

Fig. 5 Resulting strategy map
 $\alpha = 0.1; \beta = 0.1; \gamma = 0.1$

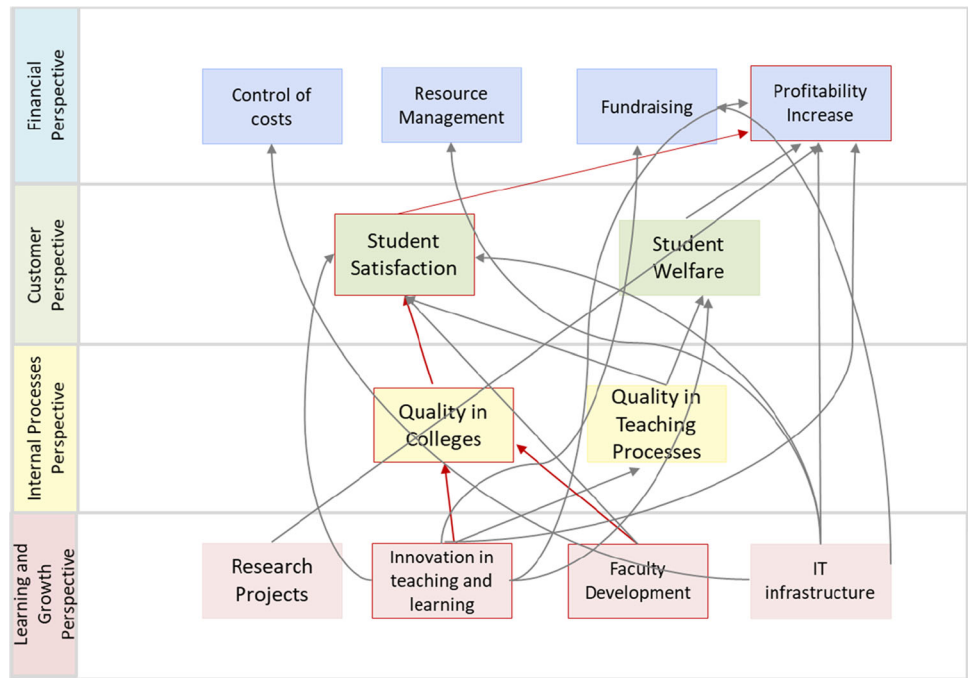
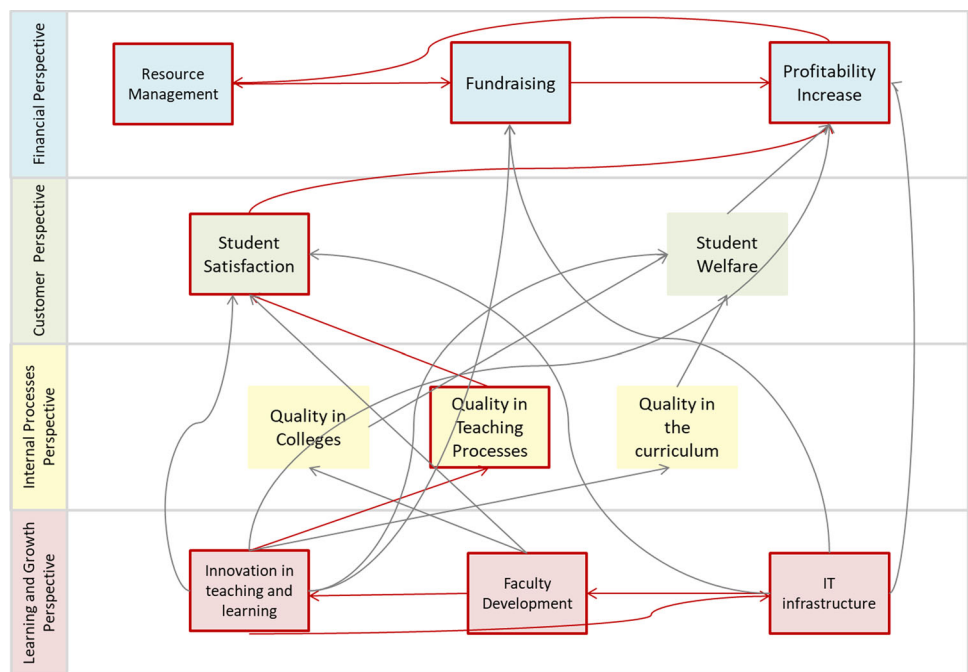


Fig. 6 Resulting strategy map
 $\alpha = 0.1; \beta = 0.1; \gamma = 0.1;$
 $T_i; S_j = 1 \forall i, \forall j$



have clarity in the assignment of the parameters' values so that they remain consistent with what is desired to reduce the relations between the strategic objectives and their prioritization or to allow a higher number of relationships and resulting objectives. Also, the cause-effect relationship that is an input for the development of the model may vary depending on the criteria that decision makers have in their organizations. These criteria modify the relations and priorities of the objectives of the BSC strategy map.

Moreover, according to the results, it is necessary to align efforts and resources to all the perspectives presented by the strategy map to guarantee the sustainability of the organization over time. Likewise, the perspectives of learning and growth and internal processes capture most of the relationships in the strategy maps, that is, they play a significant role in influencing the other perspectives. Therefore, they guarantee the fulfillment of financial objectives that allow continuity in carrying out operations

Fig. 7 Resulting strategy map
 $\alpha = 0.2; \beta = 0.2; \gamma = 0.2;$
 $T_i; S_j = 1 \forall i, \forall j$

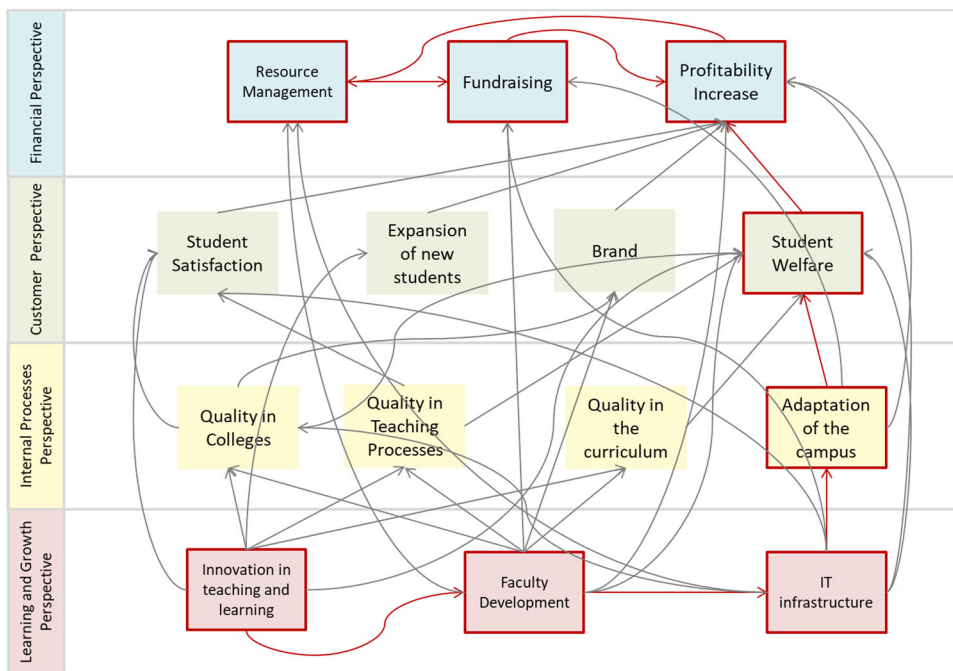


Table 14 Indicators of the resulting strategy maps

Parameters	Number of resulting relationships	Number of resulting objectives	% of importance	% of reduction of relationships	% of reduction of objectives
$\alpha = 0.2; \beta = 0.2; \gamma = 0.2$	41	16	20.46	85.61	27.27
$\alpha = 0.1; \beta = 0.1; \gamma = 0.1$	20	12	10.26	92.98	45.45
$\alpha = 0.1; \beta = 0.1; \gamma = 0.1;$ $S = 1; T = 1$	23	11	10.03	91.93	50.00
$\alpha = 0.2; \beta = 0.2; \gamma = 0.2;$ $S = 1; T = 1$	44	14	20.39	84.56	36.36

and activities. Furthermore, it is necessary to consider that experts’ profile who were surveyed influences the results of the methodology. This implies that the method is adapted to the different needs of decision makers in higher education institutions.

Considering the method itself, it seeks to reduce subjectivity by prioritizing the objectives based on their relevance in the strategy. In addition, the use of management tools, such as the strategy map of the BSC, allows clarity in planning and indicates which efforts and resources should be placed to meet the objectives that produce the greatest influence and value in the strategy in organizations. Finally, as an opportunity for future studies, it is important to consider the costs associated with the fulfillment of each objective and the budget allocated for the achievement of the organization’s strategy, thus that the organization can fully achieve its goals.

It is important to point out that the purpose of this work is to develop a method for designing strategy maps. For this reason, the numerical illustrative case to develop the strategy map presented here is only valid for the higher education institution under study. However, the method is valid for any other organization. The input is the strategy map composed of potential strategic objectives and causal relationships. The method, then, selects the strategic objectives and links between them that are important enough for being included in the final map.

In this sense, it is not possible to generate generic recommendations for educational institutions, because the outcomes are contextual and circumscribed in each particular organization. What we can affirm is that, in the case of an educational institution, managers have to carefully define the perspective to be considered and the relation among them. For example, for a public institution the main objective may be to be successful in achieving the purposes

Table 15 Resulting strategic objectives

N ^o	Objective/parameters	$\alpha = 0.2;$ $\beta = 0.2; \gamma = 0.2$	$\alpha = 0.1;$ $\beta = 0.1; \gamma = 0.1$	$\alpha = 0.1; \beta = 0.1; \gamma = 0.1;$ $S = 1; T = 1$	$\alpha = 0.2; \beta = 0.2; \gamma = 0.2;$ $S = 1; T = 1$
A1	Research projects	1	1	0	0
A2	Innovation in teaching and learning	1	1	1	1
A3	Academic publications	0	0	0	0
A4	Faculty development	1	1	1	1
A5	IT infrastructure	1	1	1	1
P1	Quality in colleges	1	1	1	1
P2	Quality in the teaching processes	1	1	1	1
P3	Quality in administrative processes for students	0	0	0	0
P4	Quality in administrative processes for employees	0	0	0	0
P5	Quality in the curriculum	1	0	1	1
P6	Cooperation between the university and the business community	0	0	0	0
P7	Cooperation between the university and other educational institutions	0	0	0	0
P8	Adaptation of the campus	1	0	0	1
C1	Student satisfaction	1	1	1	1
C2	Expansion of new students	1	0	0	1
C3	Graduate students	0	0	0	0
C4	Brand	1	0	0	1
C5	Student welfare	1	1	1	1
F1	Control of costs	1	1	0	0
F2	Resource management	1	1	1	1
F3	Fundraising	1	1	1	1
F4	Increase in profitability	1	1	1	1
	TOTAL	16	12	11	14

of clients (such as students, society, and stakeholders) and the financial perspective would be just a mean for supporting the clients. However, for a private institution the main objective may be the achievement of financial objectives, although this is not always the case, as described by Ariff et al. (2019). Having said this, it is important to point out that the design of a strategy map that represents the organization strategy is a component of a strategic management system that would support the strategic decisions of educational institutions. This reflection can be extended to other organizations with the challenge to guarantee their organizational strategic objectives.

As future research, the method could be applied in many organizations of one specific sector, for example higher educational institutions, in order to obtain general conclusions about strategic objectives in that sector. The application would also allow the improvement in the method as it is applied. It also would be interesting to prove other MCDM methods to select the strategic objectives and

relationships to be included in the strategy map and to contrast the results with the one obtained in this paper. Regarding methodological issues and the use of mathematical modeling to these kinds of topics, some questions can pave the path for future research. For instance, the integration of temporal dynamics in the formulation of strategy maps, allowing changes throughout the time (i.e., new objectives or relations) and their implications on the organizational strategy in terms of evolution or potential changes. Another example is related to the inclusion of other strategic decisions that affect strategy maps design, such as specific projects or strategic tasks, as well as the inclusion of their impacts on resource consumption (i.e., time, money) (Basar 2020).

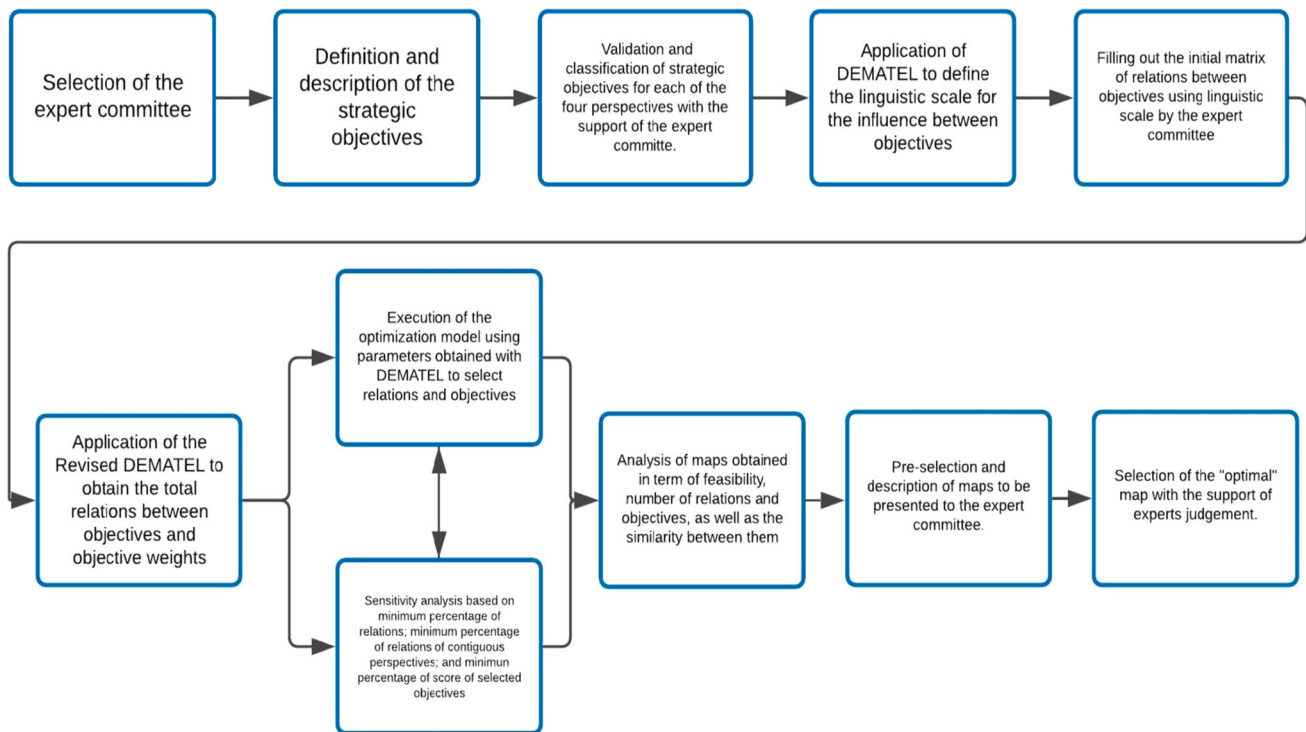


Fig. 8 Flowchart of the whole process to obtain the organization's strategy map

Appendix A

- Expert 1: Associate Professor, with 22 years of academic experience, Dottore Di Ricerca in Ingegneria (Politecnico Di Milano, 2006). She was the Academic Coordinator of Engineering and the Industrial Engineering program. Vice-president of the Latin American IISE chapter. Her area of interest is organizational management.
- Expert 2: Assistant Professor with more than 10 years of academic experience and 2 years of experience as a consultant with a Master degree in Industrial Engineering. Director of the Center for Management Systems Studies at her institution. Her area of interest is organizational management.
- Expert 3: Associate Professor with more than 20 years of academic experience. PhD in Systems Engineering. He was the Director of the Systems Engineering Department for 6 years. His research areas of interest are systemic thinking, systems simulation (agents, system dynamics) and Balanced Scorecard.
- Expert 4: Assistant Professor with more than 15 years of academic experience. PhD in Engineering. Director of the Industrial Engineering Program. His research areas are related to Organizational Management, specially applications of Balanced Scorecard.
- Expert 5: Director of the Civil Engineering Department with more than 20 years of academic and professional experience. Also, he is consultant in urban transport and strategy issues. Ph.D. in Transport Engineering of Universitat Politècnica de Catalunya and Master of Business Administration (MBA) of Universidad Toruato di Tella (Argentina).
- Expert 6: Associate professor with more than 20 years of professional experience and consultant in telecommunications, strategy and management. Ph.D. in Systems Engineering and master in Operations Management of Universidad de Chile. He was Coordinator of the Industrial Engineering program. His research areas are related to Engineering Management.

Appendix B

Source of strategic objectives.

Learning and growth perspective			
N°	Strategic area	Objective definition	Insight—source
A1	Research projects	Increase the number of research projects	Increase academic productions and develop technical knowledge (Rahimnia and Kargozar 2016) Increase the number of research projects (Valderrama et al. 2013)
A2	Innovation in teaching and learning	Train teachers in teaching and learning processes to generate constant growth	Excellence in the development of learning and learning skills (Farid et al. 2008) Excellence in teaching and learning (Papenhausen and Einstein 2006)
A3	Academic publications	Promote research publications with the aim of increasing the international profile	Increase the international profile through research publications (Cullen et al. 2003) Commercialize the achievements of research and use academic results in society; increase academic productions and develop technical knowledge; and increase the international profile through research publications (Rahimnia and Kargozar 2016)
A4	Faculty Development	Promote faculty development policies	Faculty development (Papenhausen and Einstein 2006) Didactic/learning innovations: development of a device/evaluation technique for each innovation (Hashemkhani Zolfani and Safaei Ghadikolaei 2012) Teacher development (Papenhausen and Einstein 2006) Didactic/learning innovations: development of a device/evaluation technique for each innovation (Hashemkhani Zolfani and Safaei Ghadikolaei 2012)
A5	IT infrastructure	Develop physical and virtual environments that foster cohesion and excellence for staff, students and collaborators	Information infrastructure: develop physical and virtual environments that foster cohesion and excellence of staff, students and collaborators (Hashemkhani Zolfani and Safaei Ghadikolaei 2012)
<i>Internal processes perspective</i>			
P1	Quality in Colleges	Obtain certificates and accreditations that prove the quality of academic programs, research centers, laboratories, etc	Quality of the college: credentials and evaluations of the colleges, endowed chairs, development plans for departments and colleges (Farid et al. 2008) Quality and circulation of the faculty: Faculty of quality, circulation of the faculty and the material/experiences of the class (Farid et al. 2008)
P2	Quality in the teaching processes	Create effective management of teaching which allows providing an excellent education	Improving the efficiency of teaching (Rahimnia and Kargozar 2016) Quality in teaching (Farid et al. 2008)
P3	Quality in administrative processes for students	Improve the effectiveness of services provided at the university	Efficiency and effectiveness of the service: effectiveness of student services (Farid et al. 2008) Improve service to students in accordance with national standards (Rahimnia and Kargozar 2016)
P4	Quality in administrative processes for employees	Improve the effectiveness of services provided at the university	Greater satisfaction and quality of the academic staff (Eftimov et al. 2016)
P5	Quality in the curriculum	Update the curriculum according to educational, business and commercial trends	Product quality: management of the quality of the curriculum (Wu et al. 2011) Excellence and innovation in the curriculum/program: curricular excellence and innovation; Introduction of new programs/innovations (Farid et al. 2008)

(continued)

Learning and growth perspective			
N°	Strategic area	Objective definition	Insight—source
P6	Cooperation between the university and the business community	Establish relationships with industry that allow students to approach the professional field	Contacts with companies and industry (Farid et al. 2008)
P7	Cooperation between the university and other educational institutions	Establish relations with other national and international universities that allow students to carry out exchanges	Improve and expand productive and synergistic transactions with local and international academic, social and economic institutions (Rahimnia and Kargozar 2016)
P8	Adaptation of the campus	Provide students with adequate spaces for the realization of their academic activities	Adequacy of classrooms, facilities and equipment to provide globally relevant education management (Farid et al. 2008)
<i>Customer perspective</i>			
C1	Student satisfaction	Provide services to students who meet their academic needs	Student satisfaction: ability to access the necessary courses and the ability to obtain a good job (Wu et al. 2011) Student satisfaction (Farid et al. 2008) Increase student satisfaction (Valderrama et al. 2013) Student satisfaction (Papenhausen and Einstein 2006)
C2	Expansion of new students	Increase the number of students enrolled	Expansion of new consumers (Wu et al. 2011) Increase students enrolled (Farid et al. 2008)
C3	Graduate students	Graduate professionals with high quality that adapt to the demands of society	Graduate high-quality experts, researchers and entrepreneurs according to the demands of society (Papenhausen and Einstein, 2006; Rahimnia and Kargozar 2016) Graduate high-quality students (Farid et al. 2008) Graduate high-quality students (Papenhausen and Einstein 2006)
C4	Brand	Position the university with the highest reputation	Image and reputation (Wu et al. 2011) Brand: reputation of the university (Hashemkhani Zolfani and Safaei Ghadikolaei 2012)
C5	Student welfare	Provide students with adequate spaces for carrying out their activities	Adequacy of participation in activities throughout the campus; quality of relations with other elements on campus (Farid et al. 2008) Service to the university: adequacy of the participation in the activities of the campus (Hashemkhani Zolfani and Safaei Ghadikolaei 2012)
<i>Financial perspective</i>			
F1	Control of costs	Reduce direct and indirect costs associated with the provision of faculty services	Cost control: reduction of the direct cost of products and services, reduce indirect costs and share sources with other units (Wu et al. 2011) Reduction of the direct cost of products and services; reduce indirect costs and share sources with other units (Hashemkhani Zolfani and Safaei Ghadikolaei 2012)
F2	Resource management	Allocate resources effectively to teaching, research and consulting processes	Better use and control of resources (Eftimov et al. 2016) Effectiveness in the management of resources (Rahimnia and Kargozar 2016) Resource management (Sayed 2013)
F3	Fundraising	Raise funds needed to carry out the teaching, research, and consulting activities of the colleges	Fundraising: endowment/fundraising/annual donations (Farid et al. 2008)
F4	Increase in profitability	Increase revenues from services rendered	Annual revenue growth (Tseng 2010) Income from operations: increase in research grants, increase in state ownership, increase in student rates, increase in teacher productivity (Farid et al. 2008)

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Declarations

Conflict of interest The authors declare that they have no known competing financial/ conflict of interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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