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A quantitative methodology to enhance a strategy map

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ABSTRACT

This paper presents a methodology to improve the identification of causal relationships of an existing strategy map of a company, using a multi-decision criteria method. A strategy map is one of the components of a balanced scorecard (BSC). It contains strategic objectives grouped into four perspectives and the cause-effect link between those objectives. There is no "standard" method for identifying those relationships. In many companies, they are identified conceptually, using the experience and knowledge of the company's managers.

Even though, the literature presents a number of articles using multicriteria decision methods to model a balanced scorecard, only a few of them deal with the identification of the causal relationships. However, t is assumed (by the authors) that the strategy map obtained using their method is better than strategy map that would have been obtained using only the judgment of managers. This paper does not assume that and this is the reason why the existing strategy map (or a map obtained using a qualitative approach) is combined with a map obtained by using a quantitative method to arrive to a final strategy map. This is the contribution of the paper.

The method uses the Decision-making Trial and Evaluation Laboratory (DEMATEL) method to identify the relationships of a strategy map. Then the resulting map is compared with the existing strategy map (or a map obtained using a qualitative approach). To identify the similarities and differences the K-means clustering method is used. From those similarities and differences found, it is decided which causal relationships will be included in the final strategy map. As an illustration, the application of the proposed methodology in a manufacturing company is shown.

1. Introduction

The Balanced Scorecard (BSC) developed by Kaplan and Norton (1992) is a performance measurement system that has become a strategic management tool (Kaplan, 2009), (Nudurupati et al., 2010), (Rao et al., 2018). It is a system that allows aligning the activities of the firm with its mission and strategy, improving internal and external communications, defining strategic objectives with tangible measurements, integrating quantitative and qualitative factors, finally allowing managers to focus strategic issues, both in management and execution (Lin et al., 2014).

The tools that companies use to evaluate their own performance must have some predictive features regarding future performance (Chen, 2011). BSC allows it, helping companies to focus the effort on what really will impact in the achievement of their strategic objectives. These objectives are selected according to what is required to implement the strategy and then classify it into perspectives, which help to identify the causal relationships between those objectives. The perspectives are (a) Financial, (b) Internal Processes, (c) Clients, and (d) Growth & Learning, which are aligned with the mission and strategy of the organisation. The idea of these perspectives is to combine financial and non-financial factors, covering long- and short-term strategies that measure an internal and external aspect of the business (Wu, 2012).

For most organisations, the financial perspective is the most important one, but Kaplan and Norton (2001) state that the financial performance may be improved through others perspectives. Growth & and Learning are positively correlated with Internal Processes, which are positively correlated with Clients, which in turn are positively correlated with Finances. Hence, it is necessary to focus on those objectives that have the largest influence over other objectives, improving in this way the overall performance of the organisation. In the same stream, Llach et al. (2017) found that the causal relationships in a BSC vary depending on the contextual factors of firms's size and typology.

The identification of the relationships leads to the construction of a strategy map, which helps to understand the direction of the strategy of an organisation. Jassbi et al. (2011) define a strategy map as a tool for the construction of the link between strategic objectives of the various perspectives of the BSC, representing the corresponding cause-effect. Identifying these causal relationships is a human process that combines and integrates knowledge, experience, and manager preferences.

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A number of methods have been developed for structuring the knowledge of the individuals to establish the relationships of a strategy map. They attempt to eliminate the possible ambiguity of the judgments and to consider the indirect links and the interdependency of the criteria that may exist in real life (Chen and Tzeng (2015). Apart from the method proposed by Kunc (2008), who uses systems design, the others use a quantitative approach. However, it is not possible to state that the resulting strategy map obtained using a mathematical tool has a conceptual meaning for the managers or that it is consistent with the understanding that the managers have about the business.

The quantitative methods proposed in the literature are first justified from both conceptual and mathematical points of view, and then they are applied to a real case. However, no discussion has been made about the validity of the methods. The authors assume that the resulting strategy map is the "right" one. On the other hand, it is not possible to state that a strategy map obtained without any quantitative support is "not right".

In the literature review, only one article was found in which a comparison between companies' existing strategy maps and those obtained using the Analytical Hierarchy Process (AHP) and Linear Programming (LP) was made Quezada et al. (2014). Although some similarities were found, no analysis was made to understand those similarities or differences.

This paper takes the strategy map produced conceptually by managers and modifies it by using a quantitative method based on the Decision-making Trial and Evaluation Laboratory (DEMATEL) developed by Fontela and Gabus (1974).

There are a number of methods that have been used to support the design of a strategy map. They use Multi-Criteria Decision-Making methods (MCDM), such as the Analytic Network Process (ANP) and the Analytical Hierarchy Process (AHP) developed by Saaty (2001). However, in our discussion, we focus mainly on the methods using DEMATEL, which is the MCDM method used in this paper.

MCDM methods have been used in a variety of areas. For example, Chen et al. (2011) and Gölcük (2016) utilize a technique that combines DEMATEL and ANP, measuring the intensity of the relation between different criteria under interdependence and feedback. Similar articles are those authored by Tjader et al. (2014) who use ANP under a BSC approach to support outsourcing decisions; by Tan and Kuo (2013), who analyse various objectives for recreational agencies; by Yazdani et al. (2014), who use ANP, DEMATEL and TOPSIS to establish investment strategies; and by Tsai and Li (2016), who formulate a business strategy using DEMATEL; Ozdemir, A. & Tuysuz (2017) who model a BSC for an educational institution using Fuzzy ANP and Fuzzy DEMATEL and Modaka et al. (2017) who uses Fuzzy AHP to model a BSC for supporting outsourcing decisions. Another case is presented by Chen et al. (2012), who produce a methodology to measure the performance of hot spring hotels. They also combine ANP with DEMATEL. Finally, Acuña-Carvajal et al. (2019) develop a complete strategy formulation process using fuzzy DEMATEL.

Some of the methods based on DEMATEL to design a strategy map are those proposed by Jassbi et al. (2011); Heyderiyeh et al. (2012), who establish the relationships using Fuzzy-DEMATEL, capturing the uncertainty of the decision maker when identifying the influences between objectives; Seyedhosseini et al. (2011), who utilize a BSC to implement lean manufacturing and DEMATEL to establish the priority of the lean objectives; Wu (2012) undertakes a study that presents performance indicators for banking institutions and applies DEMATEL to estimate the intensity of the relationships of the strategy map, and Rahimnia and Kargozar (2014) create and analyse a map for a university; Valmohammadi, C. & Sofiyabadi (2015) model a strategy map of an automotive company using Fuzzy DEMATEL, Lopez-Ospina et al. (2017) combine DEMATEL and Linear Programming to identify causal relationships in a strategy map and Quezada et al. (2018) combine ANP and DEMATEL to create a strategy map. Other authors, such as Shaik and Abdul-Kader (2014), Chen and Tzeng (2015), Hu et al. (2015), Lu et al. (2016), and Varmazyar et al. (2016) combine DEMATEL with other techniques to include other characteristics of the situation under study.

As mentioned previously, all the proposed quantitative methods assume that the strategy map obtained is the correct one. There is no evaluation that proves that a quantitative map is better than one obtained conceptually. To face this situation, this work considers both a strategy map created using a qualitative approach and a strategy map created using a quantitative approach. No other method has been found in the existing literature that combines both approaches. This is the contribution of this work.

2. The proposed method

2.1. Overview

The proposed methodology is based on the construction of two strategy maps, one of which has been obtained through a qualitative construction and the other one using DEMATEL. These causal relationships of both maps are used as input for the analysis of the strategic objectives to combine them in a unique strategy map.

In theory, both strategy maps should be equal, but this is not true in practices. In fact, this can be observed in the application shown in this paper. In order to estimate the ´difference' between both maps a cluster analysis is used (Mac Queen, 1967). The strategic objectives of both maps are incorporate into a model and then cluster analysis is used to group them into clusters. The clustering criteria used is the causal relationships that the objectives have with other objectives. At least in theory, the same objective (from both maps) should be included by the method in the same cluster. If not, the similarities and differences are analysis. What the proposed method does is to decide which causal relationships will be maintained and which ones will be eliminated to arrive to a unique strategy map.

Fig. 1 depicts a flow to summarize the proposed construction methodology.

2.2. The strategy map

The proposed method has as input the existing strategy map of the company, which is normally created based on the experience and knowledge of the managers and experts (Shahsavari-Pour et al., 2017). The strategy map contains the company's strategic objectives, grouped into the BSC perspectives, and the causal relationships between them. Kaplan and Norton (2000), (2004) state that the visualisation of the causal relationships between strategic objectives allows the understanding of the strategy. Hu et al. (2017) and Capelo and Dias (2009) found evidences supporting this statement through the use of laboratory experimental studies. In contrast, Strohhecker (2016) had found that a BSC report does not have an effect on strategy-implementation, compared to a traditional report. Hu et al. (2017) argues that it may be caused by the no consideration of the causal relationships of the strategy map. Similar findings had been declared by Lucianetti (2010) and Othman (2006), who found a positive impact of using a strategy map within the BSC.

If the company does not have a strategy map, it should be built as an initial step of the process. Some guidelines to build a strategy map are given by Kaplan and Norton (1992), (2001), (2004). As shown below, this was the case of the company used to illustrate the application of the proposed method. In order to describe the proposed method, the existing strategy map will be called "qualitative strategy map".

2.3. The use of DEMATEL

The input of DEMATEL is a matrix (A) containing the direct influence of factors. The objective is to obtain the total influence matrix (T) containing both the direct and indirect influences between the factors,

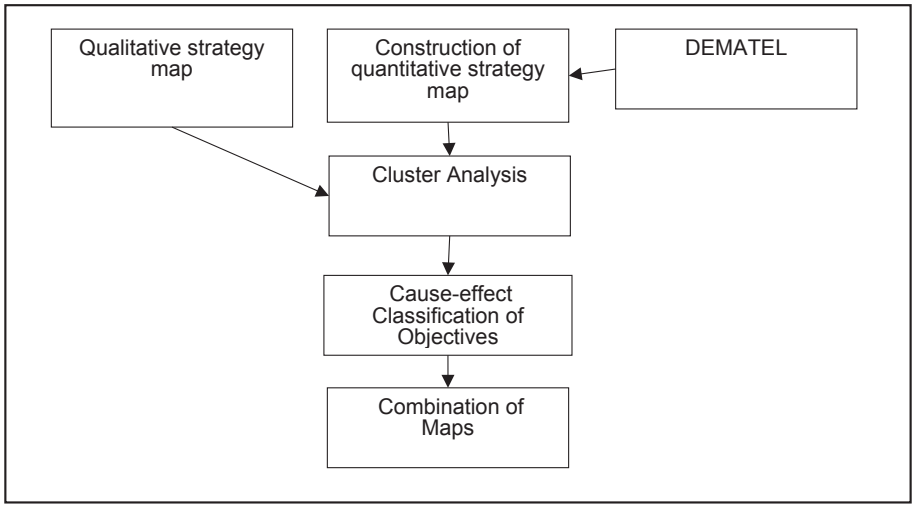

Fig. 1. Overview of methodology.

and an Impact-Relation Map (IRP) containing those influences that are important. In our case, the factors are the strategic objectives of the strategy map.

The input of DEMATEL is a direct influence matrix A that contains the direct influence between the factors. The influence is measured in a scale that ranges from 0 (no influence) to 4 (very high influence). The output of DEMATEL is a total matrix T that contains the direct and indirect influences between the factors.

Let

$$T = total\ influence\ matrix\ = [t_{ij}]\ {}^{i=1,..,n}_{j=1,...n}$$

DEMATEL computes 2 important indices:

$$r_i = \sum_{j=1}^{n} t_{ij} = sum\ of\ row\ i \tag{1}$$

$$c_j = \sum_{i=1}^{n} t_{ij} = sum\ of\ colum\ j \tag{2}$$

If r_i–c_i is positive, then factor i is affecting other factors, and if r_i–c_i is negative, then factor i is influenced by other factors. On the other hand, if $r_i + c_i$ measures the degree of relationship of the factor to other factors (receiving and affecting).

2.4. The use of cluster analysis

Clustering is an unsupervised method and it is one of the most common machine learning techniques (Celebi et al., 2013). It takes a set of points and group then into a number of clusters, using certain criteria that characterise those points. Each of these groups have a centroid and the clustering algorithm minimize the distance between every point and its centroid and maximize the distance with respect the points of other groups. In other words, the points of a specific group have similar features with its neighbours and highly different features with points of other groups. There are a two types of clustering methods: hierarchical and partitional (Jain, 2010). In the first case, the complete set of points are divided (top-down approach) or the individual points are grouped (down-top approach), both recursively in a hierarchical way. In the second case, the complete set of points are grouped into clusters simultaneously.

Among the partitional clustering algorithms, the most popular is the K-means method (Jain et al., 1999), (Jain, 2010). It is a well-known unsupervised classification technique, having been applied and evaluated in several fields ((Jain et al., 1999), and it is one of the top 10 data mining algorithms identified by the IEEE International Conference on Data Mining in 2006 (ICDM) (Wu, 2008). The method assigns the data points into K undefined clusters. This consists of iteratively finding the cluster centroids, and then assigning the data according to their distance (e.g., Euclidean) to the cluster centroids, until convergence (Attal et al., 2015).

Clustering is used to compare the causal relationships of both strategy maps. This tool reveals the differences or similarities between different maps comparing the same objective, based on the relationships of each one. These differences or similarities will serve later to classify by similarity of the effect relation to each objective on the strategy map, which will support the construction of a new strategy map by combining the state relationships of each objective, located on both the qualitative and quantitative maps. Cluster analysis sorts each objective on different clusters, where a group means that the objectives sorted on the same cluster have the same relationships with other objectives, therefore some of their relationships should be established on the new strategy map. K-means is used, because the number of clusters can be set, it is a tool that allows to verify similarities between elements, and in this case, it translates into showing if there is coherence between both maps and the way they are obtained. Furthermore, k-means have had good performance in similar purposes, compared with other supervised and unsupervised methods ((Attal et al., 2015).

2.5. Description of the method

The objective of the method is to improve an existing strategy map by combining it with a strategy map obtained using DEMATEL.

The steps of the method are:

Step 1 Construction of the Qualitative Strategy Map

Once the strategic objectives for each perspective of the BSC are established, the strategy map has to be built. This process must be carefully developed to reflect those relationships where the strategy of the organisation is better illustrated. The whole process should be carried out through meetings where the objectives' influences on the BSC are identified and evaluated by the managers of the organisation. The qualitative strategy map may have been built previously or as an initial step of the application of the proposed method.

Step 2 Construction of Strategy Map using DEMATEL

The initial influence matrix is built by answering the question: What is the influence of one strategic objective over another strategic objective? The scale ranging from 0 to 4 is used, where 0 means "no

Table 1
DEMATEL strength scale.

Value	Influence
0	None
1	Low
2	Medium
3	High
4	Very High

influence" and 4 means "very high influence", as shown in Table 1.

Using the techniques provided by DEMATEL, the total influence matrix is calculated, as well as the Impact-Relations Map. In order to reduce the number of relationships in the full influence matrix, a threshold is calculated using the average of every resulting relationship, removing the relationships below this threshold. The selected relationships are considered as the most relevant to depict the strategy of the organisation on the quantitative construction.

Step 3 Perform Cluster Analysis

In this stage we have two strategy maps: the qualitative one and the quantitative one. The first one was obtained conceptually (from the experience and knowledge of managers), while the second one was obtained using DEMATEL. It could be expected that they are equal or very similar. The differences and similarities are identified in order to combine both maps.

In order to compare both strategic maps it is necessary to focus on the elements that integrate the BSC, where each relation established between objectives can vary according to the construction, being careful to comply with the restrictions established for this purpose. For this, it is necessary to establish the similarity between each element and then sorting them into homogeneous groups, analysing each objective of each strategic map through cluster analysis.

When selecting the study variables, it is required to meet three basic conditions: the absence of correlation between each one, a bounded number of variables, and that the variable measures are not in different units. For the characteristics to be studied it is necessary to define the variables and the elements to be compared, forming a matrix with objectives, perspectives, and a category assigned to each objective.

For this study, the correlation analysis between variables is not evaluated, since each variable is necessary for the comparison, allowing to analyse if the same objective in the opposite strategy map has the same influences towards the rest, classifying them within the same cluster if this condition is accomplished. In case of correlation being identified, it is not considered redundant information because every variable is necessary to classify each element, and it is not necessary to remove or add more variables.

Let,

$$w_{ij} = \begin{cases} 1 \text{ if objective } i \text{ has an influence on objective } j \text{ in the qualitative strategy map} \\ 0 \text{ otherwise} \end{cases}$$

$$wd_{ij} = \begin{cases} 1 \text{ if objective } i \text{ has an influence on objective } j \text{ in the quantitative strategy map} \\ 0 \text{ otherwise} \end{cases}$$

$$p_{ik} = \begin{cases} 1 \text{ if objective } i \text{ belongs to perspective } k \text{ in the qualitative strategy map} \\ 0 \text{ otherwise} \end{cases}$$

$$pd_{ik} = \begin{cases} 1 \text{ if objective } i \text{ belongs to perspective } k \text{ in the quantitative strategy map} \\ 0 \text{ otherwise} \end{cases}$$

I = identity matrix

Fig. 2 depicts a matrix to explain the meaning of the entries. Obviously $p_{ik} = pd_{ik}$ ($\forall\ i, k$). On the other hand, in theory, both maps should be identical. It means that w_{ij} should be equal to wd_{ij} ($\forall\ i, \forall\ j$), because they correspond to the same objective, but in practice, it is not necessarily true.

The rows are the strategic objectives of both maps. Therefore, the rows of the matrix are twice the number of strategic objectives. The symbol "D" refers to the quantitative strategy map (obtained using DEMATEL). The columns are the objectives, perspectives, and categories. The categories form the identity matrices, meaning that each objective (i) in the qualitative map has a corresponding or "mirror" objective (j) in the quantitative map.

Cluster analysis is a multivariate technique used to group elements, looking for maximum homogeneity in each group and the greatest difference between them. This technique has no basis for making statistical inferences about a population from a sample, but it is a method based on geometric criteria used as an exploratory, descriptive, but not explanatory technique. There are different algorithms of cluster formation, grouping them into two main categories: the first is the algorithms of partition or non-hierarchical partitioning, where the set of observations is divided into k cluster, where k is defined by the user. The other algorithm of cluster formation is the hierarchical algorithms

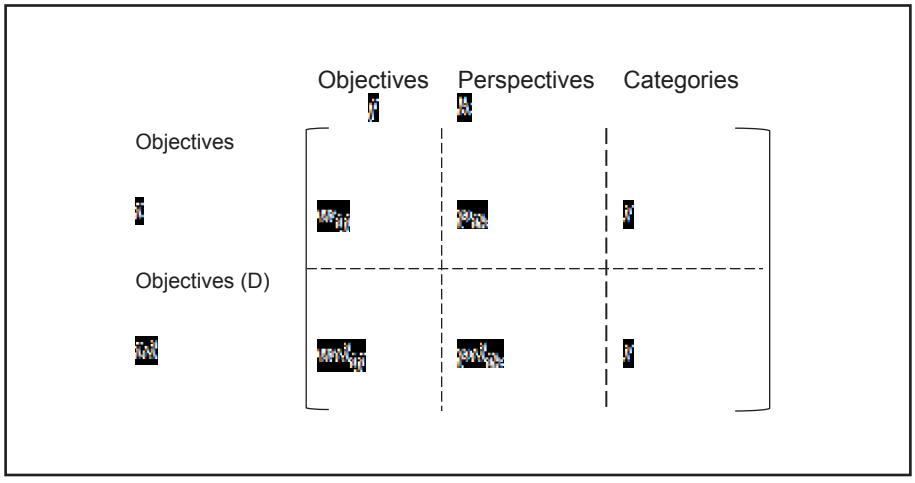

Fig. 2. Matrix of clustering variables.

that deliver a hierarchy of divisions of the set of elements. Cluster analysis is applied to the matrix using a k-means method classified as non-hierarchical (See, for example, Hair et al. (2014)). In theory, all the clusters should contain one objective of the qualitative map and the corresponding one of the quantitative map, generating as many conglomerates as strategy map objectives.

The process is as follows: a specialized software is used to perform the analysis where an initial partition is defined indicating the number of clusters, the centroid of each cluster is calculated so that the next step reassigns each element to the nearest clusters whose distance to the centre of gravity of the cluster is smaller. The k-means method is part of the reassignment methods where a case assigned to a conglomerate in one iteration can be reassigned in a later iteration, and the third step is to calculate the new centroids of the conglomerates whenever a new element is incorporated, and finally repeats the second and third steps until no reassignment allows further reduction or increase of the distance between the elements of each group. The k-mean that the cluster analysis procedure uses the Euclidean distance to measure the distance between the elements, defined by the length of the line joining the elements, this distance is an easy measure to understand, serving for continuous quantitative variables as well as for ordinal variables. However, the Euclidean distance is very sensitive to the metric of the variables. For example, if one of the measures has very large values, this will be reflected in the distance, it is advisable to typify the variables before performing the analysis. Nevertheless, for the proposed and it is not necessary to typify any variable since all are binary measures that indicate the existence or absence of some relation or characteristic of the strategic objectives.

Step 4 Perform a Cause-Effect Classification of Objectives

The strategic objectives are classified as “cause”, “effect”, or “undefined”. The classification depends on whether the objective belongs to the qualitative map or the quantitative map.

In the case of the qualitative maps, the following procedure is carried out.

Let,

$$w_{ij} = \begin{cases} 1 \text{ if objective } i \text{ has an influence on objective } j \text{ in a quantitative strategy map} \\ 0 \text{ otherwise} \end{cases}$$

$$n_i = \sum_{all\ j} w_{ij} = \text{number of causal relationships from objective } i$$

$$m_i = \sum_{all\ j} w_{ji} = \text{number of causal relationships to objective } i$$

If $n_i > m_i$ *then* objective i is classified as “cause”.

If $n_i < m_i$ *then* objective i is classified as “effect”.

If $n_i = m_i$ *then* objective i is classified as “undefined”.

In other words, an objective is classified as “cause” if the number of outgoing relationships from it is greater than the number of ingoing relationships. If both numbers are equal, then it is classified as “undefined”. Otherwise, the objective is classified as “effect”.

In the case of the quantitative map, the values of r_i *and* c_i calculated using formulas *(4)* and *(5)* of DEMATEL are applied.

If $r_i - c_i > 0$ then the strategic objective i is classified as “cause”.

If $r_i - c_i < 0$ then the strategic objective i is classified as “effect”.

If $r_i - c_i = 0$ then the strategic objective i is classified as “undefined”.

Step 5: The Combination of Strategy Maps

To establish which relationships are included in the final strategy map, the following criteria are used.

Let.

X = strategic objective of the qualitative map.

XD = corresponding strategic objective of the quantitative map.

Case 1. X and XD belong to the same cluster.

- Include all common outgoing relationships between objective X and XD.
- “Analyse” each outgoing relationship from objective X and XD if it is present in one map, but not in the other. The analysis is carried out using the procedure shown below.

Case 2. X and XD do not belong to the same cluster.

- If the same relationship goes out from X and XD, then “analyse” it using the procedure shown below.
- If a relationship is not in both maps, then ask the managers about its inclusion in the final map

Before explaining the analysis to be done, the concept of degree of causality is defined.

In a qualitative strategy map, an objective X has a higher level of causality than an objective Y if the number of outgoing relationships from objective X is greater than those going out from objective Y.

In a quantitative strategy map, an objective X has a higher level of causality than an objective Y if $r_x - c_x \geq r_{YD} - c_{YD}$. See formulas (4) and (5).

Similarly, the concept of degree of “less affected” is defined.

In a qualitative strategy map, an objective X is less affected than an objective Y if the number of ingoing relationships to objective X is less than those entering objective Y.

In a quantitative strategy map, an objective X is less affected than an objective Y if $r_x - c_x < r_{XD} - c_{XD}$. See formulas (4) and (5).

The “analysis” is the following:

- If X is a “cause” and the relationship goes to an “effect” objective, then it is included in the map.
- If X is an “effect” and the relationship goes to a “cause” objective, then it is not included in the map.
- If X is a “cause” and the relationship goes to a “cause” objective Y, and the degree of causality of X is higher, then it is included in the map. Otherwise, it is not included.
- If X is an “effect” and the relationship goes to an “effect” objective Y, and X is less affected than Y, then it is included in the map. Otherwise, it is not included.
- If X is an objective defined as “effect” or “cause” and the relationship goes to an “undefined” objective, then the managers are asked whether to include it or not.
- If X is an objective defined as “undefined” and the relationship goes to an “effect” or “cause” objective, the managers are asked about including this relationship in the new strategy map.

3. A study case

3.1. Description

The company is a manufacturing firm that produces orthopaedic products for the local market. Its vision is “To become a leader in the orthopaedic sector, focusing all the effort on the people in order to improve their life and their inclusion in society”. Its mission is “To deliver good products and services, based on close relationships with clients, meeting their needs through team-work and improving continuously the quality of the service”.

Prior to the application of the proposed method, the company had defined its strategic objectives:

3.1.1. Financial perspective

Increase Profits (F1).

Increase number of clients (F2).

3.1.2. Clients perspectives

Improve client satisfaction (C1).
Improve client loyalty (C2).

3.1.3. Internal process perspective

Improve delivery system (P1).
Improve client management (P2).
Improve product design process (P3).

3.1.4. Growth and Learning perspective

Strengthen TI Culture (G1).
Improve worker competencies (G2).
Improve motivation (G3).
Increase teamwork (G4).

3.2. The qualitative strategy map

The input of the proposed methodology is the existing strategy map. The company did not have one, so it was necessary to produce it during a process of formulating a business strategy for the company. One of the authors acted as a facilitator of the process. Fig. 3 depicts the resulting strategy map.

3.3. The quantitative strategy map

To build the quantitative strategy map, the managers were asked about the degree of influence between objectives. This process led to the direct influence matrix shown in Table 2. The application of DEMATEL leads to the total influence matrix, which is shown in Table 3.

A threshold is defined as the average of the entries of this matrix. The final matrix contains those entries that are greater than the threshold value. The resulting strategy map is depicted in Fig. 4.

Table 4 shows the relationships that each map presents, where 0 indicates the existence or absence of a relationship in both maps, 1 indicates an existing relationship in the quantitative map but not in the qualitative one, and −1 in the opposite case.

It is seen that the quantitative map presents 15 relationships that in the qualitative map do not exist, with 80% of these relationships concentrated in the learning and growth perspective, while the rest are in the internal process perspective, inasmuch as the qualitative map shows four relationships that are not in the quantitative map. In summary, the quantitative strategic map compared to the qualitative strategic map concentrates the relationships in the learning and growth perspective, agreeing with the objectives given by the managers that the company was in a process of change.

Table 2
Direct influence matrix (A).

Objective	F1	F2	C1	C2	P1	P2	P3	G1	G2	G3	G4
F1	0	0	0	0	0	0	0	0	0	0	0
F2	3	0	0	0	0	0	0	0	0	0	0
C1	1	3	0	4	0	0	0	0	0	0	0
C2	2	3	0	0	0	0	0	0	0	0	0
P1	3	0	1	0	0	0	0	0	0	0	0
P2	3	3	1	3	1	0	0	0	0	0	0
P3	2	2	1	0	0	2	0	0	0	0	0
G1	2	0	1	0	2	0	1	0	4	1	2
G2	0	2	2	2	2	2	3	2	0	1	1
G3	0	1	1	1	1	1	0	1	2	0	3
G4	1	1	2	2	2	2	1	1	2	1	0

3.4. Cluster analysis

The next step of the method is the application of cluster analysis. The SPSS™ was used. In this case, there are 11 strategic objectives, so this number will also be the number of clusters. On the other hand, the number of cases for the clustering process is twice the previous number. The matrix of clustering variables is shown in Table 5.

The result is shown in Table 6, where it is seen, for example, that objectives F1 and F1D, both representing the strategic objective "Increase profits", belong to the same cluster. However, objective P3 and P3D, both representing the same strategic objective "Improve product design process" belong to a different cluster. It means that the objective has a different behaviour in both maps and requires to be analysed.

3.5. Cause-Effect Classification

The cause-effect analysis led to the results shown in.

Table 7, where "1" in the last column means that the corresponding objectives are of the same type (cause or effect), and 0 otherwise.

As an example, objective F1 of the qualitative map was classified as "effect", because the number of outgoing causal relationships was **0** and

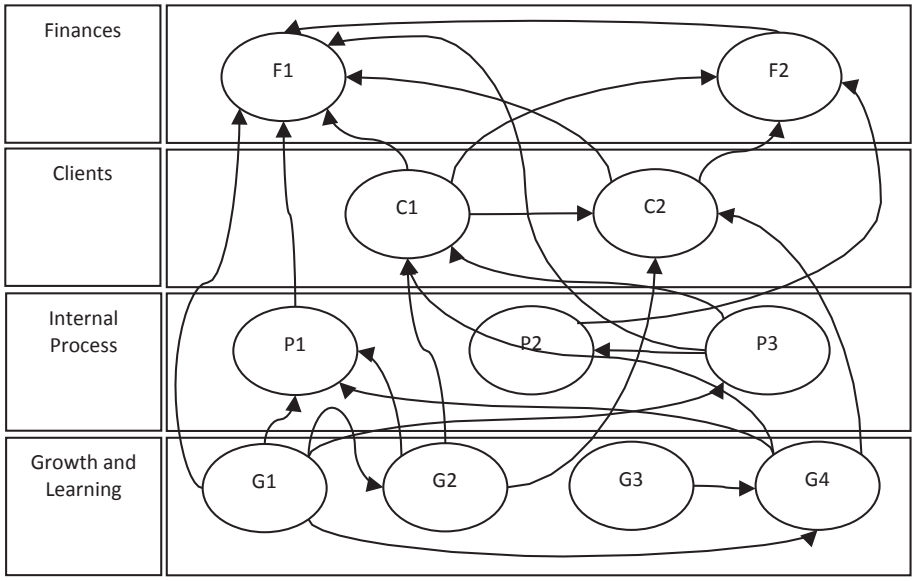

Fig. 3. Strategy map of the company.

Table 3
Total influence matrix (T).

Objective	F1	F2	C1	C2	P1	P2	P3	G1	G2	G3	G4
F1	0	0	0	0	0	0	0	0	0	0	0
F2	0.176	0	0	0	0	0	0	0	0	0	0
C1	0	0.218	0	0.235	0	0	0	0	0	0	0
C2	0.149	0.176	0	0	0	0	0	0	0	0	0
P1	0.184	0	0	0	0	0	0	0	0	0	0
P2	0.252	0.221	0	0.191	0	0	0	0	0	0	0
P3	0.175	0.156	0	0	0	0	0	0	0	0	0
G1	0.231	0	0.139	0	0.183	0	0	0	0.275	0	0.155
G2	0.182	0.254	0.177	0.209	0.164	0.162	0.199	0	0	0	0
G3	0	0.166	0	0.152	0	0	0	0	0.166	0	0.202
G4	0.205	0.188	0.172	0.211	0.162	0.154	0	0	0.15	0	0

the number of ingoing causal relationships was 6. In the same way, objective F1 of the quantitative map was also classified as “effect”, because its value of r was lower (0) than its value of c (1.55) (See Table 3).

3.6. Combination of strategy maps

In **Error! Reference source not found.**6 it is seen that the corresponding objectives classified in the same clusters are: “F1” with “F1D”, “F2” with “F2D”, “C1” with “C1D”, “C2” with “C2D”, “P1” with “P1D”, “P2” with “P2D”, “G1” with “G1D”, and “G3” with “G3D”.

Those common relationships of these objectives are maintained in the new strategy map, while, the non-common relationships have to be analysed according to the classification shown in.

As an example, the combination of objectives Improve client management (P2) of each map is chosen. This objective has one outgoing relationship on the qualitative map, which goes to objective F2, while the same objective on the quantitative map has three outgoing relationships which go to F1, F2 and C2. As can be seen, those objectives have one relationship in common which goes to the F2 objective, hence this relationship has to be maintained in the combined strategy map. On the other hand, the non-common relationships are analysed using the classification of each objective. In order to decide whether to maintain those relationships, it is necessary to know the classification of objectives P2, F1, and C2, which are undefined, effect, and effect, respectively. Since objective P2 is undefined, the relationships between F1 and C2 have to be consulted with the managers.

Table 4
Quantitative and qualitative difference matrix.

Quantitative - Qualitative											
	F1	F2	C1	C2	P1	P2	P3	G1	G2	G3	G4
F1	0	0	0	0	0	0	0	0	0	0	0
F2	0	0	0	0	0	0	0	0	0	0	0
C1	−1	0	0	0	0	0	0	0	0	0	0
C2	0	0	0	0	0	0	0	0	0	0	0
P1	0	0	0	0	0	0	0	0	0	0	0
P2	1	0	0	1	0	0	0	0	0	0	0
P3	0	1	−1	0	0	−1	0	0	0	0	0
G1	0	0	1	0	0	0	−1	0	0	0	0
G2	1	1	0	0	0	1	1	0	0	0	0
G3	0	1	0	1	0	0	0	0	1	0	0
G4	1	1	0	0	0	1	0	0	1	0	0

The next objectives which were classified in the same cluster have to follow the same process as in the example shown.

In the same way, the relationships of the objectives “P3”, “P3D”, “G2”, “G2D”, “G4, and “G4D” have to be analysed according to the classification of.

Table 2, because the pair of mirror objectives are classified in different clusters.

Selecting the objective Improve product design process (P3) as an example of the combination process for those objectives which were not classified in the same cluster, it is seen that the outgoing relationship to objective F1 appears in both strategy maps. However, the relationships

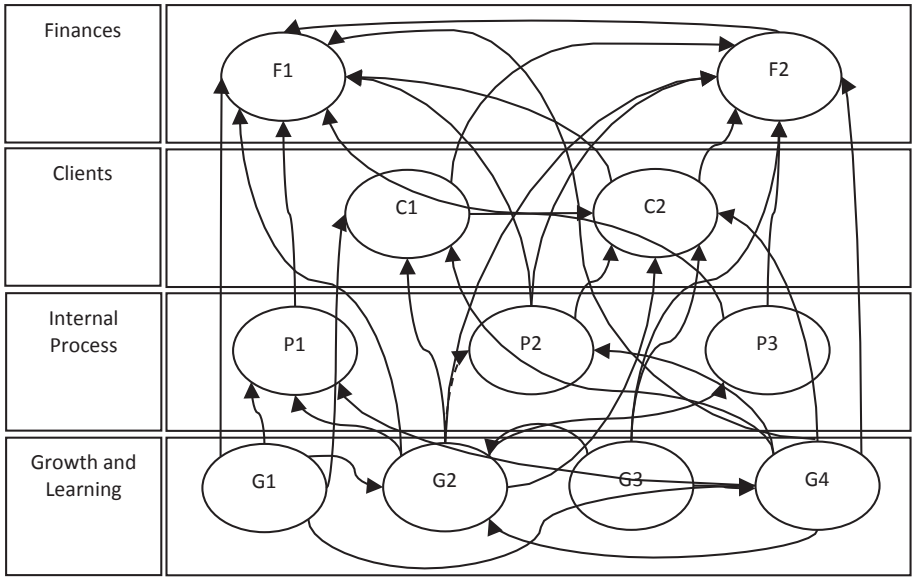

Fig. 4. Quantitative strategy map.

Table 5
Matrix of clustering variables.

Objective	F1	F2	C1	C2	P1	P2	P3	G1	G2	G3	G4	F	C	P	G	CT 1	CT2	CT3	CT 4	CT 5	CT 6	CT 7	CT 8	CT 9	CT 10	CT 11
F1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
F2	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
C1	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
C2	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
P1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
P2	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
P3	1	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
G1	1	0	0	0	1	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
G2	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
G3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
G4	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
F1D	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
F2D	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
C1D	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
C2D	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
P1D	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
P2D	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
P3D	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
G1D	1	0	1	0	1	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
G2D	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
G3D	0	1	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
G4D	1	1	1	1	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1

Table 6
Result of cluster analysis.

Case	Objective	Cluster	Case	Objective	Cluster
1	F1	1	12	F1D	1
2	F2	1	13	F2D	1
3	C1	3	14	C1D	3
4	C2	4	15	C2D	4
5	P1	5	16	P1D	5
6	P2	6	17	P2D	6
7	P3	7	18	P3D	6
8	G1	8	19	G1D	8
9	G2	9	20	G2D	2
10	G3	10	21	G3D	10
11	G4	9	22	G4D	11

Table 7
Cause-effect classification.

Node	Qualitative	Quantitative	Combination
F1	Effect	Effect	1
F2	Effect	Effect	1
C1	Un-Defined	Effect	0
C2	Effect	Effect	1
P1	Effect	Effect	1
P2	Un-Defined	Cause	0
P3	Cause	Cause	1
G1	Cause	Cause	1
G2	Cause	Cause	1
G3	Cause	Cause	1
G4	Cause	Cause	1

with F2, C1, and P2 do not appear in both maps. Those relationships which go to an undefined objective are consulted with the managers, the same as with the relationships towards objectives C1 and P2, whose decision is shown below. In regard to relationship P3–F2 it is necessary to analyse this according to the classification and level of causality or effect of each one. Objective P3 is classified as “Cause” and objective F2 is classified as “Effect”, thus this relationship has to be maintained in the combined strategy map according to the previous analysis presented.

The same procedure is necessary for the following objectives classified in different clusters, in order to obtain the combined strategy map.

A total of 17 relationships were consulted with the managers, ten of which correspond to relationships involving undefined objectives corresponding to C1 and P2, while the remaining seven correspond to objectives P3, G2, and G4, classified in different clusters. It is important to emphasize that the answers given arise from the knowledge of the managers about their business.

The consulted relationships related to undefined objectives are shown:

Improve client satisfaction– Increase profits (C1–F1): This relationship is identified in the qualitative map. It is maintained because the company must have a close relationship with its customers in order to provide good quality service.

Improve client management – Increase profits (P2D-F1D): This relationship is founded on the quantitative map. However, it is not maintained in the combined strategy map because client management does not have a direct impact on profits according to the experience of the managers.

Improve client management –Improve client loyalty (P2D-C2D): This relationship is identified in the quantitative map. This relationship is conserved in the combined strategy map because every decision made on client management is designed in order to improve the response of the clients about the company.

Improve product design process – Improve client satisfaction (P3–C1): This relationship is identified in the qualitative map, and is maintained because the product design process is strongly related to client satisfaction.

Improve worker competencies – Improve client satisfaction (G2-C1): This relationship is presented both on the qualitative and the quantitative map, and is maintained because the worker's knowledge about the business may change the client's perceptions at the moment of ordering an orthopaedic product.

Increase teamwork – Improve client satisfaction (G4-C1): This relationship is also presented in both strategy maps, and it is also maintained, because teamwork generates a good working environment, improving the quality of the service delivered to customers.

Improve product design process – Improve client management (P3–P2): This relationship is presented in the qualitative map, and it is maintained because the product design process impacts on client management.

Strengthen TI culture - Improve client satisfaction (G1D-C1D): This relationship is presented in the quantitative map and is eliminated by the managers because the use of TIC is not an element perceived by the

clients.

Improve worker competencies – Improve client management (G2D-P2D): This relationship is presented in the quantitative map and it is eliminated because the worker's competencies do not have a great impact on client management.

Increase teamwork – Improve client management (G4D-P2D): This relationship is presented in the quantitative map and it is eliminated because client management is not an element that can be improved through teamwork.

The relationships consulted for objectives classified in different clusters correspond only to relationships established in the quantitative map, which are shown below:

Improve product design process – Increase number of clients (P3D-F2D): This relationship is maintained because through a better product design process a greater number of customers can be reached.

Improve worker competencies – Increase profits (G2D-F1D): This relationship is maintained because worker competencies avoid any type of waste in the operation of the business.

Improve worker competencies - Increase number of clients (G2D-F2D): This relationship is eliminated because workers competencies do not have a direct impact on the number of clients.

Improve worker competencies - Improve product design process (G2D-P3D): This relationship is eliminated because workers competencies are not considered to have influence on the product design process.

Increase teamwork - Increase profits (G4D-F1D): This relationship is maintained because teamwork improves the use of resources in the operation of the business.

Increase teamwork - Increase number of clients (G4D-F2D): This relationship is eliminated because teamwork is not related to the number of clients.

Increase teamwork - Improve worker competencies (G4D-G2D): This relationship is maintained because teamwork allows information transfer among workers, giving the possibility of knowing activities developed by other workers and increasing the knowledge about the business.

4. The strategy map

Fig. 5 shows the resulting strategy map. The strategy map obtained contains 30 causal relationships, 15 of which are between nonadjacent perspectives, seven belong to the same perspective, and eight are between adjacent levels. The objective with the higher number of incoming links is “Increase Profits”, followed by “Increase number of Clients” and “Improve Loyalty of Clients”. In relation to objectives that are “cause”, the most importants are “Strengthen TI Culture”, and “Increase Team Work”.

Each objective of the new strategy map can be classified according to its level of cause or effect in order to know its role in the company's strategy. This classification will help the managers to aim their efforts based on the obtained strategy map.

Table 8 shows the classification of each objective.

The managers should concentrate most of their action on the Cause objectives, the majority of which are concentrated in the perspectives of Growth and Learning and Internal Process. These actions will affect the objectives classified as Effect, which can be found in the perspectives of Financial, Clients, and Internal Process.

Moreover, it is possible to highlight some objectives per perspective depending on the outgoing and ingoing relationships, and this means that it is possible to identify objectives which are more “sensitive” or more “influential” inside the perspective regardless of the remaining objectives. In other words, some decisions could take a long time to see some kind of result, so then the managers ought to consider the most influential objective inside the perspective that they seek to improve and make a decision over it. In the same way, if managers need to control some perspective, they should watch the most sensitive objective in it.

In this study case, inside the Financial perspective, Improving the number of clients is the objective which has more outgoing relationships, so some actions can be made over this objective. In the same perspective, the Increase profits objective has the largest number of ingoing relationships compared to the rest of the objectives of the strategy map, so this objective should be controlled by the managers to see the impact of every decision. Inside Client perspective, Improve client satisfaction has more outgoing relationships than Improve client loyalty, and the latter has the highest ingoing relationships, so this objective should be controlled by the managers. In Internal Process perspective, the objective Improve product design process has the highest number of outgoing relationships and Improve delivery system has more ingoing relationships than the rest of objectives in the same perspective, so the former should concentrate some of the action taken and the latter ought to be the objective to be controlled in this perspective. Finally, in the Growth and Learning perspective, the objectives Improve use of TICs and Increase teamwork have the same and the highest amount of outgoing relationships as the rest of the objectives on the strategy map, so the managers should aim their efforts over these objectives. In the same way, the objectives Improve worker competencies, and Increase teamwork are those with the largest amount of ingoing relationships, so they are the objectives that should be controlled in this perspective.

In fact, it is possible to choose the most important perspectives for the company, which are the results obtained in Financial and Client perspectives which control the following objectives: Increase profits, Increase number of clients, and Improve client loyalty as the top three criteria with more incoming relationships, while the efforts should be concentrated on Improve use of TICs, Increase teamwork, and Improve product design process, key objectives to this type of business, which concentrate the outgoing relationships towards the rest of the strategy map.

Comparing the obtained strategy map with the company's initial one, some changes related to the objectives which the managers should control or at which they should aim their efforts are seen. One of the changes happens inside the Client perspective, where, in the qualitative objectives map, C1 and C2 were the objectives that should be controlled inside this perspective, while in the new map it should be only objective C2. The second change occurs inside the Growth and Learning perspective, where initially objective G1 was the one with the majority of the outgoing relationships and in the new map G1 does not change, but G4 is considered now equally important as G1. Furthermore, objective G4 was considered the objective with more ingoing relationships, and in the new map a new objective is added, so G2 and G4 are the objectives which should be controlled inside this perspective.

This method helped focus the strategy on the changes that the company was going through at that moment. These changes can be seen specifically in the Growth and Learning perspective, adding the objective Increase teamwork as one of those having most influence inside this perspective, and Improve worker competencies as one of the most important effect objectives inside the same perspective. Another change that is seen occurs inside Client perspective, where Improve client satisfaction is removed as one of the most important effect objectives inside this perspective. So this method prioritizes Growth and Learning, a perspective that the managers wanted to improve due to the changes experienced at that moment.

In terms of the appreciation of the managers about the obtained strategy map, they consider that this is helpful to perform every activity inside the business, because it is complex to make a decision not knowing the impacts over other areas. Then their comments about it are positive because it decreases the arbitrariness of the decision, showing the main picture of each interaction among the objectives. In addition, sometimes managers obtained good or unexpected results inside the business, but most of them could not know the root that triggered these effects, making it impossible to keep the good results and/or improve

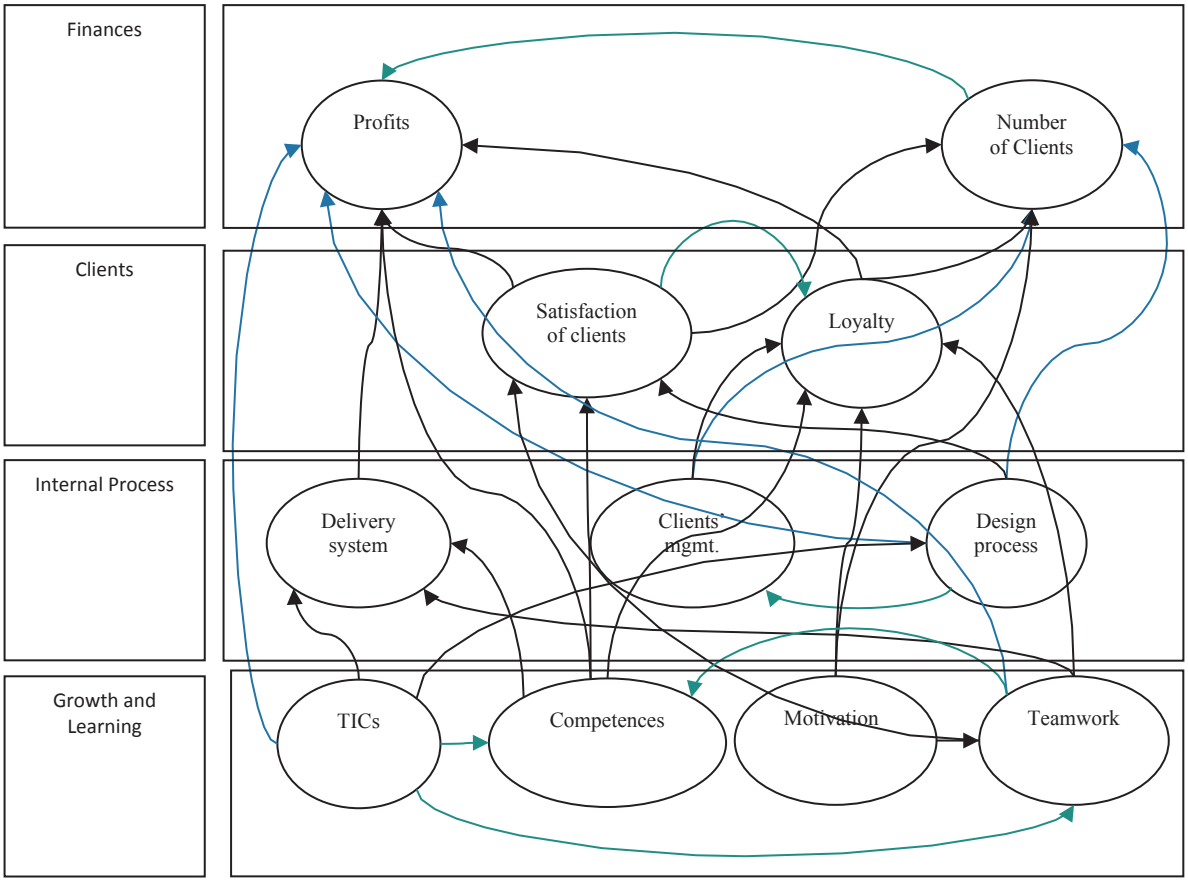

Fig. 5. The final strategy map.

Table 8
Combined strategy map classification.

Objective	Symbol	Classification
Increase profits	F1	Effect
Increase number of clients	F2	Effect
Improve client satisfaction	C1	Cause
Improve client loyalty	C2	Effect
Improve delivery system	P1	Effect
Improve client management	P2	Cause
Improve product design process	P3	Cause
Strengthen TI Culture	G1	Cause
Improve worker competencies	G2	Cause
Improve motivation	G3	Cause
Increase teamwork	G4	Cause

the bad ones. Regarding the application of the method, the managers said that each of the guided steps was easy to understand as the objective to accomplish, but the application of this method was considered demanding, so it should be carried out in companies with a level of complexity that would make the task performed worthwhile.

Regarding the management implications, it could be said that the proposed method enhances an existing strategy map. The advantage of the method is that it takes into account the experience and judgment of the managers of the company and then guide them through a quantitative approach to improve it. It should be remember that the method maintain those relationships that are present in both maps (qualitative and quantitative) and then focuses on those relationships that are different in both maps. In some cases, when the difference between both maps is small, the method itself makes a decision about the inclusion of a relationship in the final map. However, when that decision is not clear, managers are asked to analyses the relationships to make the decision. This process is very important, because it encourages managers to make a discussion of the meaning of the relationships. In this way, the method gives the confidence that the final strategy map actually represents the strategy of the company.

It also should be remember, that both strategy maps were built by people from the company and both should represent the strategy of the company. In practice they are not equal, because some reasoning made by managers was different when they were built. The method attempts to unify that reasoning.

5. Conclusions and further research

This paper presents a method to identify the causal relationships in a strategy map. It combines a map built with conceptual considerations with a map built using DEMATEL. The method was created because the existing literature describes a large number of quantitative methods to create strategy maps, without questioning if they are valid or appropriate for the company. On the other hand, the books and papers where a non-quantitative method is used, the maps were made conceptually by managers. The resulting strategy map using the method proposed here is aimed at identifying what relationships from both strategy maps should be maintained or deleted.

On the other hand, the analysis of strategy maps is useful to obtain a map that takes as its starting point the knowledge of the decision maker of your organisation, without directly using a tool to establish relationships, where some influences are seen altered due to the questionnaire under which relationships and their intensity are established. However, the classification of the nodes in relation to their nature of cause Table 7, where “1” in the last column means that the corresponding objectives are of the same type (cause or effect), and 0 otherwise. or effect, together with the cluster analysis, prevents the

decision maker from completing a comprehensive review of all the relationships established in the strategy map at the time of the combination, focusing attention only on conflicting relationships that involve nodes that do not maintain their classification among strategic maps.

The method allows the decision maker to carry out an evaluation of the relationships present in the qualitative map (it could be the existing one). After the analysis it is possible to add new relationships or delete those that are not important for the strategy of the company aiming to improve an existing strategic map, resulting in a strategic map that is robust and understood by the decision maker.

The application of the method in a manufacturing company which produces orthopaedic products for the local market is described. Managers found that the method was easy to understand and the resulting strategy map represented the strategy of the company.

Of course, the work has some limitations, which opens the possibility of doing further research. First, the qualitative strategy map is created using DEMATEL. The application of other methods, such as the Analytic Network Process (ANP) and the Analytic Hierarchy Process (AHP), could be explored. Second, to compare both strategy maps, the K-means clustering method was used. Other clustering mechanisms could be used and analyse. In fact, at this stage it is not possible to establish if the clustering method used would have an impact on the strategy map obtained.

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