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A method for designing a strategy map using AHP and linear programming

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ABSTRACT

This paper presents a method to support the identification of the cause-effect relationships of strategic objectives of a strategy map of a balanced scorecard. A strategy map 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 issue addressed in this paper is the identification of those relationships, topic in which the existing literature is scarce. A previous work was revisited, which uses the Analytic Hierarchy Process (AHP) to establish the "importance" of the arcs (relationships) of a strategy map. That work then deletes those arcs with an importance lower than a given threshold level defined by the authors. This paper goes beyond by selecting the arcs using a multi-objective linear programming model (LP). The model has two objectives (a) to minimize the number of selected relationships and (b) to maximize the total importance of the selected relationships. It is interested to see that a trade-off between both objectives is produced, so a control variable is used to incorporate the importance given to both objectives by managers. The paper also shows some applications of the method and their analysis.

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1. Introduction

The Balanced Scorecard (BSC) developed by Kaplan and Norton (1992, 1996) in the 1990s is a performance measurement system that has evolved to become a complete strategic management system (Kaplan and Norton, 2001a, 2001b). The BSC has been very popular among practitioners as well as in the literature (Gomes et al., 2004; Neely, 2005; Nudurupati et al., 2010).

The main contribution of the BSC is that it includes strategic objectives and performance measures that are not solely financial. The BSC considers four perspectives, where strategic objectives and performance measures are defined: (a) Financial, (b) Clients, (c) Internal processes, and (d) Learning and growth. There is a causal relationship among these perspectives: If the learning & growth perspective is improved, then the internal processes perspective will be improved. There is also a positive effect on client's perspective which will ultimately have an impact on the financial perspective. Measures that are a result of past actions or events and measures representing actions that will have an impact in the future are also included. The *return on investment* is an example of the first situation while the *amount invested in increasing workers competences* is an example of the second. A more detailed description of those relationships is included in what is called a *strategy map*, in which strategic objectives are connected to represent the causal relationship between them (Kaplan and Norton, 2004). Some authors such as Nørreklit (2000, 2003) and Bessire and Baker (2005) have criticized the validity of strategy maps, but Banker et al. (2011), through an experiment with students enrolled in an MBA program, found that a strategy map had a positive impact in the effective use of a BSC.

As in this study, the Analytic Hierarchy Process (AHP) and its extension, the Analytic Network Process (ANP) (Saaty, 2001, 2002), to model a Balanced Scorecard have been applied to model a BSC in many studies. One of the advantages of AHP and ANP is that they allow the combination of tangible and intangible factors, which is a characteristic of a BSC.

Examples of these applications are the studies carried out by Leung et al. (2006), who developed AHP and ANP models of a BSC, taking into account the time-dependency of the measure and the one developed by Sarkis (2003), who utilized ANP to model a BSC to establish all the factors influencing performance measures. In the same way, Yuan and Chiu (2011) used a case-based reasoning (CBR) system to obtain weights for the elements of a BSC. They compared their results with the results obtained using AHP. They argued that their method reached to more effective performance

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measurements. Yüksel and Dagdeviren (2010) designed a fuzzy ANP to model the BSC of a manufacturing company to evaluate the performance of a business. Hsu et al. (2011) used an ANP to incorporate the sustainability issue in a BSC. Huang et al. (2011) used AHP to prioritize the strategic objectives of a BSC in a pharmaceutical firm. Bentes et al. (2012) built an AHP model of a BSC of a company to evaluate the performance of three business units. Tjader et al. (2014) designed a BSC using an ANP for a case company, in which the alternatives of the model were IT outsourcing strategies.

The issue addressed in this paper is how to identify the causal relationships of a strategy map. Only a few papers were found relative to this subject. One of the papers is the work reported by Kunc (2008), who used a method based on strategic thinking (Senge, 1999) to create a strategy map. Quezada et al. (2009) developed a method for designing this map based on the way firms design this map in practice. Other methods are quantitative and use multi-criteria methods to identify the relationships between the strategic objectives. Yang et al. (2008) used the Decision Making Trial and Evaluation Laboratory (DEMATEL) technique to establish causal-effect relationships between policies affecting innovative companies. Jassbi et al. (2011) used fuzzy DEMATEL to model the relationships within a strategy map, even though they did not describe how to derive the strategy map in their analysis. Wu (2012) used DEMATEL to create a strategy map. It is interested to note that in the case presented, some key performance indicators (KPI) have reciprocal feedbacks, i.e., they affect themselves, which is because DEMATEL is able to capture complex relationships that may exist in a BSC. This is because, this tool allows the identification of both direct and indirect impacts. Other authors such as Tsen (2010) and Chen et al. (2011) combined ANP and DEMATEL to model and analyze a BSC. These two authors do not explain how to obtain a strategy map from their analysis, even though both argue that it is possible to build one using their proposed methods.

In all the papers found in the literature regarding BSC in which AHP or ANP is used, the causal relationships are already predefined. However, the objective of the method presented in this paper is to identify those relationships. When DEMATEL is used, authors have to specify a "threshold level" to establish when a relationship is important enough to be considered within a strategy map, something that is not required in the method presented here.

This work combines AHP and linear programming (LP) to design a strategy map of a BSC. AHP is used to assign priorities to all the possible relationships within a strategy map and LP is used to select those that are "important" that will ultimately be included in the strategy map.

The combination of AHP/ANP and LP has been applied in many studies, particularly to the subject of evaluation and selection of suppliers. AHP and ANP have been used mainly to prioritize the factors affecting the decision, while LP has been used to optimize the evaluation or selection, incorporating constraints or conditions that are necessary to meet at the same time (Ghodsypour and O'Brien, 1998; Amid et al., 2011; Ghodsypour and O'Brien, 2001; Demirtas and Üstün, 2008; Demirtas and Ustun, 2009; Lin, 2012; Lin et al., 2011; Kokangul and Susuz, 2009; Shaw et al., 2012).

An important conclusion reported by Leung et al. (2006) is expressed as "We show that the AHP and the ANP can be tailor-made for specific situations and can be used to overcome some of the traditional problems of BSC implementation". This conclusion is important because, in practice, a strategy map does not necessarily fit the structure of the four dimensions defined by Kaplan and Norton (1992), so the method presented here can also be tailored to specific characteristics of a firm.

The work by Quezada and Quintero (2011) who used the AHP to model a strategy map serves as the basis for the method proposed in this study. In their model, nodes represent strategic objectives and directed arcs represent causal relationships. They use the AHP to estimate the priority of each one of the arcs, and then they select those arcs (for inclusion in the strategy map) that have a priority higher than a given threshold value. This method is summarized in Appendix A. The contribution of this work is the utilization of a linear programming model to select the links for a strategy map.

2. The method

In general, the method uses the AHP to estimate the importance of the relationships between the strategic objectives, and then it selects those relationships that are important enough to be included in a strategy map. The purpose of the AHP depends on the problem. It can be used to set up relationships and calculate probabilities, etc., but it is most commonly used to identify priorities. In this study, we use it to model relationships.

The proposed method has three main stages:

Stage 1: Modeling the strategy map as a hierarchical model.
Stage 2: Estimating of the importance of each one of the relationships.
Stage 3: Selecting the relationships which are "important"

Stage 1 and stage 2 are the same as the stages used by Quezada and Quintero (2011) in their method. This paper proposes a different method for carrying out the third stage.

2.1. Stage 1

The first stage corresponds to the representation of a strategy map in the form of a hierarchical model. In that model, all the nodes between consecutive hierarchical levels are connected among them. Fig. 1 depicts an example of a hierarchical model representing a strategy map. Level 1, level 2, level 3 and level 4 represent the financial, clients, internal processes and learning & growth perspectives, respectively, even though the levels may be tailored to the situation of a specific company. A level 0 with only one node has been added for the purpose of the estimation of the importance of the nodes within the level 1. The nodes represent

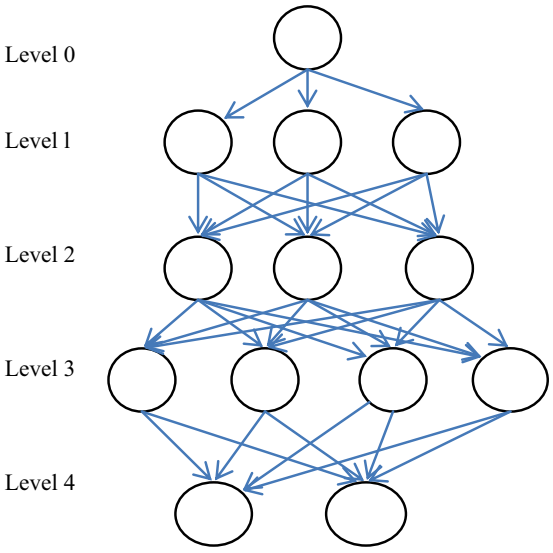

Fig. 1. Initial representation of a strategy map using a hierarchical model.

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