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

Luis E. Quezada a,⁎, Héctor A. López-Ospina b

a Department of Industrial Engineering, Faculty of Engineering, University of Santiago of Chile (USACH), Avenida Ecuador 3769, Estación Central, Santiago, Chile
b Faculty of Engineering and Applied Science, University of Los Andes, Monseñor Álvaro del Portillo 12445, Las Condes, Santiago, Chile

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A B S T R A C T

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) financial, (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 interesting 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 Narreklit (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.
AHP or ANP is used, the causal relationships are already pre-
proposed methods. Even though both argue that it is possible to build one using their
analysis, Wu (2012) used DEMATEL to create a strategy map. These two authors
their analysis. Other authors such as Tsen (2010) and Chen et al. (2011) combined
affect themselves, which is because DEMATEL is able to capture
performance indicators (KPI) have reciprocal feedbacks, i.e., they
affirmative 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 pre-
deﬁned. 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 condi-
tions 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 tail-
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 impor-
tance 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.](image-url)
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