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Setting competitiveness indicators using BSC and ANP

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In this paper a new approach to assess companies' competitiveness performance in an efficient and reliable way is presented. It introduces a rigorous methodology, based on multi-criteria techniques, which seeks to assist managers of companies within a specific industrial sector in providing information about their relative position in order to define improvement action plans. The approach combines the use of the analytic network process (ANP) method with the balanced scorecard (BSC) to achieve competitiveness indicators. The ANP method allows the aggregation of experts' judgments on each of the selected indicators used into one company competitiveness index (CCI). To demonstrate the goodness of the methodology, a case study of the plastic sector of Venezuela has been carried out. Three companies have been analysed using the CCI proposed. The participating experts agreed that the methodology is useful and an improvement from current competitiveness measurement techniques. They found the results obtained coherent and the use of resources significantly less than in other methods.

Keywords: analytic network process (ANP); competitiveness indicators; BSC; group decision

1. Introduction

Competitiveness, benchmarking and management systems are approaches that have been used by companies since the end of the twentieth century to contribute to the improvement of the companies themselves, the industrial sector or the country with the aim of becoming competitive. In the past, entrepreneurial competitiveness measurement only depended on financial indicators. But recently it has also included factors such as innovation, learning and entrepreneurial capabilities as well as management indicators. The works carried out by Liedtka (2005), Jalali Naini *et al.* (2010) and Grigoroudis *et al.* (2011) add indicators related to quality, productivity, raw materials and others things to the financial indicators. According to Gunasekaran and Kobu (2007) measuring intangibles and non-financial performance measures pose a greater challenge in the new enterprise environment. Sirikrai and Tang (2006) suggest that the use of both financial and non-financial performance indicators creates a more accurate performance measurement system because it offers a more complete view of a business and can therefore lead to better-informed business decisions. They propose five competitiveness indicators: manufacturing excellence, added value of products, market expansion, financial returns and intangible values of the company.

In another sense, Hult *et al.* (2003) argued that four culture-based factors–entrepreneurship, innovativeness, market orientation and organisational learning – collectively give rise to an organisation's culture competitiveness.

Porter (1997) defines competitiveness as the ability of a business to systematically maintain the differentiating advantages that allow it to reach, sustain and improve a given socioeconomic position. Porter's approach assumes that every company that competes in an industrial sector possesses a competitive strategy. This strategy can be developed explicitly through a process of strategic planning or implicitly through the aggregated activity of the different functions of the company. Based on this second assumption, the value chain can be defined as a conceptual structure that helps to diagnose the sources of competitive advantage. In this sense business analysis is based on the analysis of the company's value chain.

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Augusto *et al*. (2006) say that in a highly competitive market the organisation must engage in a systematic benchmarking process aimed at enhancing performance in the context of continuous improvement. To this end, the organisation should possess a system that includes a planned model that measures the characteristics and parameters of multifaceted performance. Any competitiveness measurement system should contain a number of specific indicators approved by experts.

On the other hand, authors like Thakkar *et al*. (2007) propose the use of management systems as analysis tools that help relate the company's competitive strategy to its performance indicators. These authors consider that the balanced scorecard model (BSC) provides an appropriate framework to translate the company's strategic objectives into a set of coherent performance indicators. The main advantage of BSC is the close relationship between the company's strategic and the different internal and external, financial and non-financial indicator clusters. Additionally, Öztaysi and Ucal (2009) say that BSC is the most suitable technique for measuring business performance due to its great success in the professional and academic world when aligning competitiveness indicators with business objectives.

BSC's goal is to develop a competitiveness measurement system based on the definition of specific competitiveness indicators selected by experts. According to Porter's model (1995), such indicators will consider the factors forming the chain value of the company as main source for the identification of competitive advantages. Additionally it is convenient to use the four aspects of Kaplan and Norton's BSC model as a framework to help in the generation of the indicators.

To this end, prioritisation of companies according to their level of competitiveness has to be considered as multidimensional in nature due to the multifaceted nature of economic and business performance. Gathering and considering the different opinions and judgments of their managers is also a difficult task intrinsic to these processes (Hult *et al*. 2003). While the literature deals extensively with the issues of competitiveness indicators, it lacks a prescription for an easy-to-use, yet rigorous methodology for ranking companies in a systematic, practical and proven way. Finally, when the information available is biased and uncertain, as is the case in industrial competitiveness scenarios, it is necessary to make estimates. In such cases, experience and knowledge of the problem are more important than the prioritisation model itself. Therefore, it is preferable to focus efforts on finding a renowned group of experts and getting them involved in the process.

The results of the prioritisation process will provide information about the positioning of each company in the sector, which will allow the company to define the corresponding adjustments or changes in its internal processes to differentiate or fit in the market and thus ensure its long-run successful sustainability and improved customer services.

Furthermore, for a model to be accepted, it has to arise from an agreement among the stakeholders as much as possible. Otherwise some of the involved agents may feel the assessments biased. Thus, they may not support the results obtained according to the model. Since the model has to be able to measure multifaceted performance characteristics, some of which are intangibles, our approach will be based on multi-criteria techniques, specifically the analytic network process (ANP).

To help managers assess the competitiveness of their companies, a new multi-criteria approach (MCDA) based on the analytic network process technique and the participation of a group of experts is proposed.

The rest of the paper is arranged the following way: in Section 2 a review of the applications of MCDA techniques to the field of this research is carried out, in Section 3 the bases of the ANP model are described, in Section 4 the methodology of the study is proposed, Section 5 develops the case study and in the last section conclusions are extracted.

2. The use of MCDA techniques for companies' competitiveness measurements

Competitiveness measurement is a challenging task aiming at enhancing performance in the context of continuous improvement. To accomplish this task, companies must have an organisational system based on analytical models designed to measure multifaceted performance characteristics (Augusto *et al*. 2006). MCDA techniques are very appropriate for solving this type of problem. The expression MCDA is used as an umbrella term to describe a number of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter (Belton and Stewart 2002). More information about MCDA can be found in Belton and Stewart (2002) and Barba-Romero and Pomerol (2007).

Several authors have recently introduced the use of MCDA techniques in companies' competitiveness measurements. Most of these studies focus on building decision models and developing decision-making methods. Many of them use the analytic hierarchy process (AHP) (Saaty 1996), which has been accepted as a leading multi-criteria decision model (Reisinger *et al*. 2003, Sirikrai and Tang 2006, Shahin and Mahbod 2007, Temur *et al*. 2007, Lee *et al*. 2008) to assign priorities to the criteria or indicators involved, with Reisinger *et al*. (2003) and Lee *et al*. (2008) applying balanced scorecard to the performance measures. Others introduce the use of outranking techniques such as ELECTRE (Roy 1996) in order to avoid the compensation problem of traditional methods (Augusto *et al*. 2006). This compensation problem is inherent to all aggregation methods based on sums: an extreme value of one criterion may compensate the moderate values of other criteria giving a global result that may not correspond to the experts' opinion. All these MCDA techniques work well under the assumption of the independence of criteria. However, this assumption is not always realistic, and certainly not in the field of competitiveness measurement where multiple related dimensions of information have to be considered in the analysis. Thus, bias can occur when using any of these methods, and this can lead to non-optimal evaluations. For this reason, the analytic network process is chosen as it takes into account the interdependence among criteria and, to a great extent, avoids the problem of compensation.

ANP is a method proposed by Saaty. It provides a framework for dealing with decision making or evaluation problems. It presents its strengths when working in scenarios with scarce information, as is the case of competitiveness measurement contexts. Similar to AHP, ANP is based on deriving ratio-scale measures to be used to allocate resources according to their ratio-scale priorities, whereas ratio-scale assessments, in turn, enable considerations based on trade-offs (Keeney and Raiffa 1976). AHP models assume a top-down relationship among decision levels, which means that bias could occur when the criteria and subcriteria are correlated with each other. However, ANP does not require this strictly hierarchical structure and allows for more complex inter-relationships among the decision levels. ANP generalises the problem modelling process using a network of criteria and alternatives (all called elements), grouped into clusters. All the elements in the network can be related in any possible way, that is to say a network can incorporate feedback and interdependence relationships within and between clusters. This provides an accurate modelling of complex settings and allows handling the usual situation of interdependence among elements in company evaluation scenarios.

In the literature there are some applications involving ANP in the field of competitiveness. From among those found, some are related to company performance measures (Lin *et al*. 2009, Yang *et al*. 2009), others to strategic e-business decision analysis (Raisinghani *et al*. 2007) and others still to customer relationship management in e-commerce companies (Öztaysia *et al*. 2011).

Some of these applications integrate BSC with ANP and also use fuzzy logic. In these cases the four BSC perspectives are used as a framework to measure companies' competitiveness performance on the basis of considering not only financial indicators but also non-financial indicators (Leung *et al*. 2006, Tseng 2010, Yüksel and Dagdeviren 2010, Hsu *et al*. 2011). Specifically, the last one incorporates sustainability indicators to the BSC model. In all of these works the ANP model is composed of clusters grouped according to the four BSC perspectives and their dependence relationship. There are also applications based on a combination of BSC with ANP in the same way but outside the field of competitiveness measurement, that is to say applied to new product development (Lee *et al*. 2007). However, to our knowledge, no application based on the aggregation of experts' judgments and which considers interaction among indicators has been found.

It is very important to count on the participants involved throughout the evaluation and interpretation processes and use of the results. Therefore, the aim of this proposal is not to substitute the work of any of the management team members but on the contrary to ease and facilitate it. The experts' opinions and judgments are the only ones to be taken into account and to be the input data in the evaluation model.

3. Theoretical background of the ANP model

The analytic hierarchy process and the analytic network process are two methods proposed by Saaty (1980, 1996, 2000, 2005, 2008). AHP is a well-known technique, widely used and conceptually easy to use. However its strict hierarchical structure cannot address the complexities of many real-world problems. As a solution, Saaty proposed the ANP model, a generalisation of AHP. ANP represents a decision-making problem as a network of criteria and alternatives (all called elements), grouped into clusters. The influence of the elements in the network on other

elements in that network can be represented with a supermatrix. This new concept consists of a two-dimensional element-by-element matrix which adjusts the relative importance weights in individual pairwise comparison matrices to build a new overall supermatrix with the eigenvectors of the adjusted relative importance weights.

According to Saaty (2005), the ANP model comprises the following steps:

(i) Identifying the components and elements of the network and their relationships.
(ii) Conducting pairwise comparisons on the elements.
(iii) Placing the resulting relative importance weights (eigenvectors) in pairwise comparison matrices within the matrix (unweighted matrix).
(iv) Conducting pairwise comparisons on the clusters.
(v) Weighting the blocks of the unweighted matrix by the corresponding priorities of the clusters, so that it can be column-stochastic (weighted matrix).
(vi) Raising the weighted matrix to limiting powers until the weights converge and remain stable (limit matrix).
(vii) Obtaining the element prioritisations according to any of the columns of the limit matrix.
The priority of each alternative (company) is a dimensionless value that will be considered the company competitiveness index (CCI).
(viii) Once the results are obtained, in the event that some alternatives achieve very similar results, carrying out a sensitivity analysis in order to demonstrate the robustness of the ranking obtained.

In order to endow the results with a higher value, it is advisable to have several experts involved in solving the problem of prioritisation. In this case three experts, all members of the management staff of the company, have been contacted.

4. Methodology

The methodology proposed in this study applies the industrial competitiveness measurement to each sector, following the proposal of Ellis *et al.* (2002), who suggest that the measurement's indicators depend on the type of industrial sector and the competitiveness level perceived by each sector. This methodology allows the definition of a number of competitiveness indicators based on the performance and setting of an industrial sector, as well as their implicit relationships. In this way it is possible to obtain a competitiveness index that allows a company to know its relative position with respect to other companies in the sector and to establish a ranking of the companies in order of their competitiveness level within that particular industrial sector.

The methodology proposed here is based on three main aspects:

- The competitiveness model defined by Porter (1995).
- The BSC system developed by Kaplan and Norton (2000).
- The multi-criteria ANP model developed by Thomas Saaty (2005) which allows modelling the decision problem as a network of inter-related elements (indicators and companies in our case study).

(Figure 1) shows the five stages of the methodology proposed in this study.

Stage 1: Analysis of the value chain of the industrial sector

The value chain of the companies in the sector that covers all the functions of the company consists of: suppliers, purchases, operations, marketing, sales, customers, human resources and finance depending on the products and services provided (Porter 1995). The analysis of the components of the value chain allows us to define the factors that more strongly affect company competitiveness (Spendolini 1994). The components of the value chain are used to lay the foundations for the competitive performance of the industrial sector.

Stage 2: Definition of the experts in the industrial sector

Following Aragonés-Beltrán *et al.* (2008), this methodology proposes taking into consideration the opinion of several experts in order to provide a more objective prioritisation. In this way the information comes from the opinions of experts with a lot of experience in and in-depth knowledge of the sector. When the information available is uncertain it is necessary to make estimates. In such cases, experience and knowledge of the problem are more

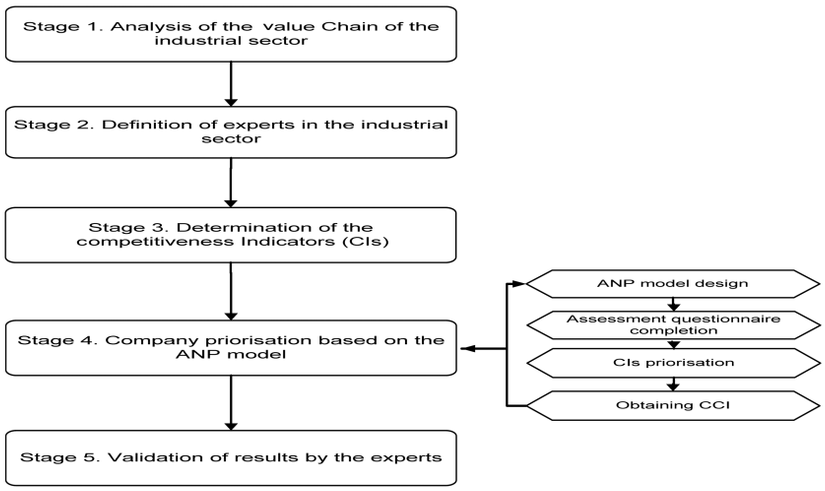

Figure 1. Proposed methodology.

important than the prioritisation technique itself. Therefore, it is preferable to focus the efforts on finding a group of proficient experts and get them involved in the process.

Stage 3: Determination of the competitiveness indicators (CIs)

According to Augusto *et al.* (2006), companies should possess a model that measures the characteristics and parameters of multifaceted performance through a number of specific indicators approved by experts (for more details see Section 1). After the analysis of the value chain, the group of experts determines which factors are more influential on the competitive performance of the company and defines the competitiveness indicators. These CIs should be defined in a participatory workshop through discussion and subsequent agreement. The four aspects of Kaplan and Norton's BSC model (2000) are used as a framework of the analysis to help in the definition of the indicators.

Stage 4: Company prioritisation based on the ANP model

The aim of this step is to obtain an index for each company which indicates the level of competitiveness according to all the indicators considered, the company competitiveness index. The higher the value of the index, the more competitive the company is.

This stage covers the following steps.

4.1: Definition of the ANP model. Five components or clusters are built up. The first four correspond to CIs (ANP criteria) grouped according to the four BSC factors. The fifth component corresponds to the companies in the industrial sector (ANP alternatives).

4.2: With the help of the experts, the influence of each element of the model on the others (indicators and companies) is determined using Saaty's scale (Saaty 1980) for the pairwise comparisons through questionnaires specifically designed for that purpose.

4.3: The individual experts' judgements are processed using Super Decisions© software for the calculations described in Section 3. The aggregation of the individual judgements will be carried out by means of the geometric mean (Saaty 1980).

4.4: With this method, a dimensionless value is obtained for each element of the model. The value indicates the importance of the competitiveness indicators in the evaluation model as well as the relative position of the company in the sector compared to that of the other companies, the CCI.

Stage 5: Validation of the results by the experts

The results obtained are discussed in order to define patterns that help in the implementation of plans for improving the company's competitiveness system.

5. Case study

The methodology is applied to three companies in the plastic sector in Venezuela. The model is applied to the plastic industrial sector because it has grown dramatically in recent years (more than 400 companies, according to data supplied by the Asociación Venezolana de Industrias Plásticas), (AVIPLA 2008) due to a substantial increase in the production of its raw material, that is to say resin, as a consequence of the great investments in the production of this oil by-product in Venezuela.

The aim of the model is to obtain a competitiveness index for the companies of the case study in order to compare their relative position in the sector. The model will allow the prioritisation of the companies depending on the index obtained.

For the competitiveness measurement among companies it is necessary to select companies belonging to the same industrial segment and with similar features for their valid comparison or prioritisation, as defined by Porter (1997), in the creation of industrial associations: groups of companies with similar products and services that associate to reach a common goal. The industrial segment selected for the present study is packaging. Packaging concentrates a substantial consumption of resin as its main raw material.

Stage 1: Value chain

The packaging segment, which comprises more than 100 companies, can be classified into different categories:

- Product type: there are printed and non-printed bag manufacturers, bags made from different resins like polypropylene (PP), low-density polyethylene (LDPE), high-density polyethylene (HDPE), linear LD polyethylene (LLDPE), individual bags, bags in rolls and bags with printing and/or lamination.
- Customer type: food, pharmaceutical, agriculture and packaging.
- Manufacturing capability.
- Whether they are packaging manufacturers or suppliers.

Fernández (2004) mentions some common features of the plastic companies:

- Simple organisational structure of the family type.
- The raw material is national with a single supplier: PEQUIVEN – Petroquímica de Venezuela.
- They are members of industrial associations like AVIPLA, Corplami and Carpa.
- Financial support by the government.
- Strategic location for marketing.
- Fiscal incentives to promote exportation.
- Many non-qualified workers.

Packaging factories have two main types of customers: suppliers, who are in charge of the commercialisation of generic litter bags, and direct customers. The latter are manufacturers that require some kind of packaging for their products.

The supply chain is oriented towards manufacturing companies that work upon regular orders from their customer portfolio with a low merchandising level and medium production technology.

Stage 2: Selection of experts

For the goal of the study – prioritisation of companies and indicators for competitiveness measurement in the plastic packaging sector – the experts selected possess in-depth knowledge of the plastic sector of Venezuela, management systems and competitiveness levels. Knowing the profile required for the experts (see Section 4, stage 2), and together with the CEO of AVIPLA, three experts were chosen.

- Expert one: The CEO of AVIPLA and entrepreneur with more than 25 years of experience in the plastic sector.
- Expert two: University teacher with much experience as general manager in companies in the petrochemical and plastic sectors. In-depth knowledge of the implementation of BSC in these companies.
- Expert three: General manager of a company in the plastic sector with much experience in the implementation of BSC. He belongs to the management board of AVIPLA.

Stage 3: Competitiveness indicators

At this stage a selection of the indicators that represent the expectations of the sector and the factors that more significantly affect the companies' competitive performance is carried out. With the collaboration of the experts during two face-to-face participatory workshops, a total of 17 indicators were finally selected and grouped according to the four BSC aspects. The first session lasted two hours, in which the experts were shown the value chain and its key areas. The session focussed on discussions about key areas, particularly manufacturing processes, training, innovation levels and the competitiveness indicators associated with them. From this first session a total amount of 47 indicators were chosen.

In the second session the experts were asked to reduce the number of indicators through consensus. After two hours of discussion, a total amount of 17 relevant indicators were selected.

The competitiveness indicators selected were:

A. Customers:

(1) Participation in the market: Sales per year in tons/demand in tons.
(2) Rate of new customers: Sales to new customers in tons/total sales per year in tons.
(3) Maintaining customers: Number of last year's customers that remain this year/total number of last year's customers.
(4) Delivery time: Average difference between delivery and order dates.

B. Learning and growth:

(1) Maintaining workers: Number of workers that work for more than two years in the company/total number of workers.
(2) Training level of the workers.
(3) Strategic decision making of the organisation (measured on a 1–9 scale: 1 non-influential, 9 highly influential).
(4) Innovation capability of the workers (measured on a 1–9 scale: 1 non-influential, 9 highly influential).

C. Internal process: This component refers to the identified critical processes relative to competitiveness.

(1) Computation and systems platform: Updating and efficiency degree (measured on a 1–9 scale: 1 non-influential, 9 highly influential).
(2) RM (polypropylene, polyethylene) waste rate: Waste rate in tons/total tons of RM used per year.
(3) Productivity: Total number of employees and workers/total number of annual tons sold.
(4) New Services: Annual implementation of new customer services (financing, home delivery and so on).
(5) Social responsibility and environmental defence: Percentage of income allocated to plans of social responsibility and environmental defence, before paying taxes.

D. Finance: We selected the most relevant financial indicators in financial management and competitiveness.

(1) Liquidity: Measured by (active – stock)/passive. It must be greater than one.
(2) Profitability: Net utility of taxes/heritage.
(3) Debts: Total debt/heritage.
(4) Sales of new products: Sales of new products in tons/total sales per year in tons.

Stage 4: Company prioritisation based on the ANP model. Company competitiveness index

The company is a system composed of interrelated subsystems. The indicators measure the competitive performance of the subsystems. Therefore, if the subsystems have some kind of influence on each other, the competitive indicators will too. The group of experts were interviewed and informed about the ANP methodology and its applications in criteria and the alternative prioritisation during a group session by the facilitator. They were asked to assess the model and suggest changes, which were taken into account in its final design. After solving every question asked by the experts, an individual questionnaire was designed and sent by email to each of them using pairwise questions in order to allow comparison analysis. The group of experts identified the relationships or influences among the 17 indicators. Their results are shown in (Figure 2).

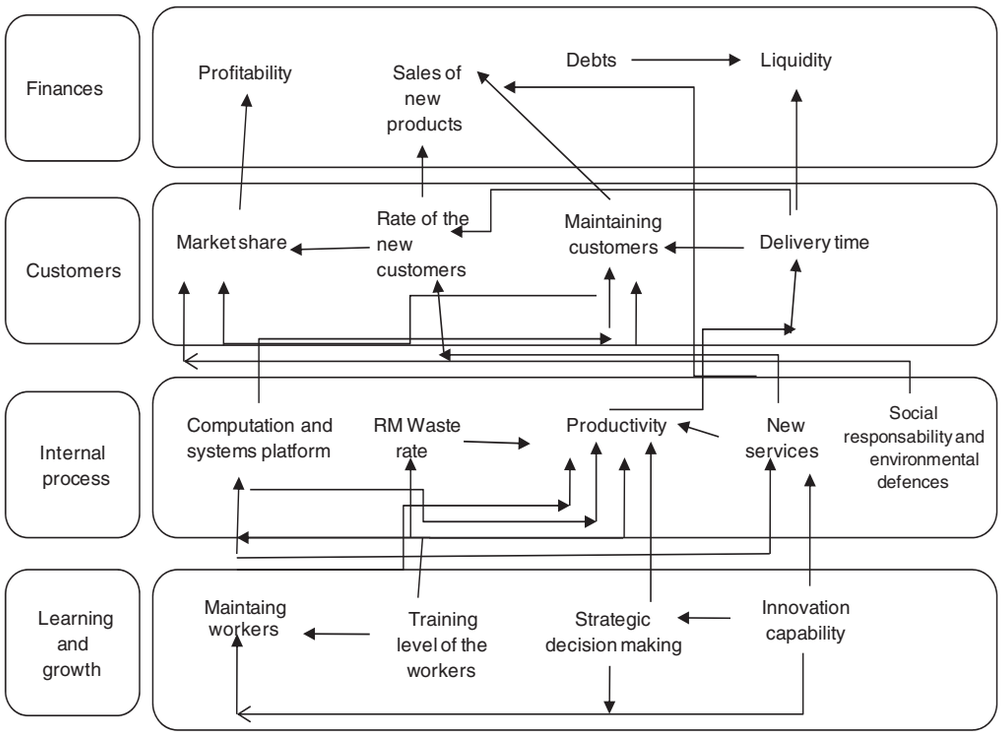

Figure 2. Diagram of influences among competitiveness indicators.

(Figure ▮) reveals feedback among the following components: customers, internal process and learning and growth. On the other hand, experts also identified influences among the elements of the four components, for example: the training level of the workers has an influence on productivity, which in turn has an influence on delivery time, which in turn has an influence on maintaining customers and liquidity. Another example is: the training level of the workers has an influence on the development of new services, which in turn has an influence on the rate of new customers, which in turn has an influence on participation in the market, which in turn has an influence on profitability.

These relationships have been used to build the ANP model for the case study, including a fifth component that contains three companies belonging to the plastic sector whose competitiveness level is to be evaluated. Feedback among the selected companies is neglected. The companies are denoted as A, B and C.

These companies were selected by the experts under the criteria of small- to medium-sized enterprises with at least 50 workers, leaders and competitors among them in the field of plastic packaging. They also had to use similar methods of manufacturing and marketing techniques. In short, these companies should be comparable to each other and clearly identified in the value chain built for the sector.

With the help of Super Decisions© (Superdecisions 2009), a software program that performs matrix calculations, the model that represents the ANP-based diagram of influences shown in (Figure 3) was developed.

According to relationships shown in (Figure 3) the influence matrix was built up. This matrix transforms the influential relationships of (Figure 3) into a matrix with values 0 and 1 – see (Table 1).

At this stage and through questionnaires answered by the experts, the degree of influences among the indicators was obtained using Saaty's 1–9 scale (Saaty 2000).

An example of the questionnaire designed to allow for the comparison analysis is shown in (Figure 4).

Based on the geometric mean value of the judgements assessed by each expert, the original supermatrix containing the eigenvalues resulting from the submatrices generated by pairwise comparison of the elements or indicators is modelled. (Table 2) shows the values of the resulting supermatrix.

With the weights of the components and the original supermatrix, the limit matrix is constructed raising the weighted matrix to limiting powers until the weights converge and remain stable. So, the weights of the 17 indicators and the position of the three companies under study are obtained.

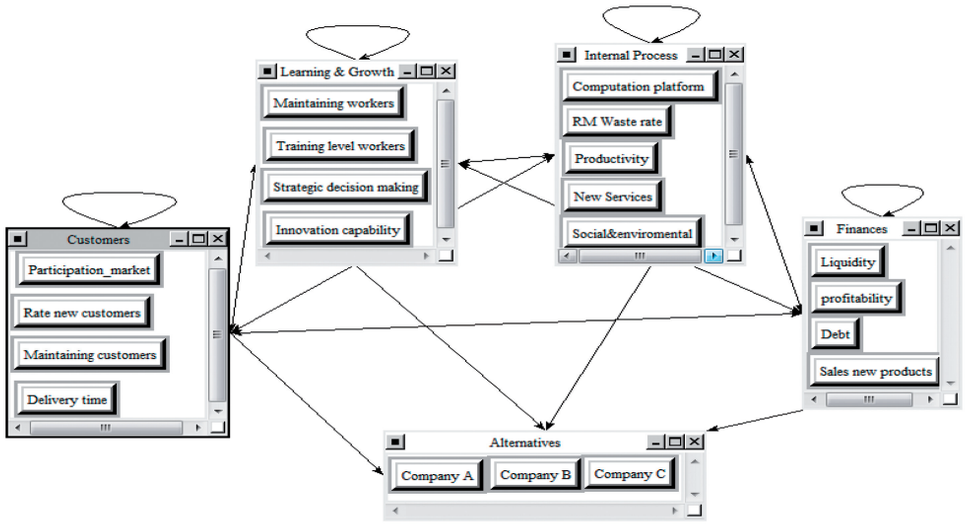

Figure 3. Diagram of the ANP model.

The results of the prioritisation of the three companies in terms of competitive performance places Company A in the first position with a CCI of 43.87%, Company C in second position with a CCI of 29.36%, and third is Company B with a CCI of 26.75%.

Stage 5: Data validation by the experts

Regarding the results obtained for the criteria

(Figure 5) summarises the hierarchy of the competitiveness indicators provided by the three experts. This figure shows the competitiveness indicators sorted by weight or relative priority on the competitiveness in the plastic industrial sector.

These global results show that, according to the experts, the most important criterion is sales of new products with 12.52% of the weight, closely followed by productivity (12.49%), innovation capability (12.19%) and training level of workers (11.44 %). The three least important criteria are debt (0.42%), liquidity (0.21%) and maintaining workers (0%).

A revision of the results provided by each expert reveals that they agree on the selection of competitiveness indicators though they do not fully agree on the weights allocated to the indicators.

It seems that experts 1 and 3 show an agreement in their prioritisation of indicators. The profiles presented in (Figure 7) of these two experts are quite aligned. The reason for that, in our opinion, is that they both have entrepreneurial-oriented opinions, while the other one is more academic oriented. However, all three experts agree that indicators of maintaining workers, liquidity, debt and social responsibility and environmental are the least important.

Regarding the results obtained for the companies

(Figure 7) shows the relative position of the companies according to each expert and according to the aggregation of the experts' judgements based on the geometric mean value. The three experts agree that Company A occupies the first position. The combined selection represents an agreed decision among the experts, as shown in the (Figure 7).

A sensitivity analysis to test the robustness of the results of the companies' ranking was performed. For that, the weight of the three most important criteria (productivity, innovation capability and training level of workers) has been changed ±15%. The results show that with these slight changes, Company A does not change its dominant position. However there is a rank reversal in the second and third positions. This was expected since both companies had virtually tied.

Table 1. Influence matrix.

		Customers				Learning				Internal					Finances				Alternatives		
		C1.1	C1.2	C1.3	C1.4	C2.1	C2.2	C2.3	C2.4	C3.1	C3.2	C3.3	C3.4	C3.5	C4.1	C4.2	C4.3	C4.4	C5.1	C5.2	C5.3
Customers	Participation in the market	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
	Rate new customers	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0
	Maintaining customers	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0
	Delivery time	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Learning	Maintaining workers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Training level of workers	0	1	1	1	1	0	1	0	1	1	1	1	0	0	0	0	1	0	0	0
	Strategic decision making	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Innovation capability	0	0	0	1	1	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0
Iinternal processes	Computing platform	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
	RM waste	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0
	Productivity	0	0	0	1	0	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0
	New services	1	1	1	0	0	1	0	0	1	1	1	0	1	1	0	0	1	0	0	0
	Social & environmental resp.	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
Finance	Liquidity	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
	Profitability	0	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	0
	Debts	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Sales of new product	1	1	1	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0
Alternatives	Company A	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
	Company B	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
	Company C	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		0	0

With respect to company A for each pair of linkage competitiveness indicators please indicate, which of the two you consider to be most influential and to what extent.

The competitiveness indicators must be compared pairwise, by asking to what degree criterion Ci has a bigger influence compared with criterion Cj, using the following scale (Saaty's scale):

Cij = 1: indicator i and indicator j are considered to be equally influential

Cij = 3: indicator i is considered to be slightly more influential than indicator j

Cij = 5: indicator i is considered to be significantly more influential than indicator j

Cij = 7: indicator i is considered to be far more influential than indicator j

Cij = 9: indicator i is considered to be absolutely more influential than indicator j

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C1.1: Participation in the market

C1.2: Rate of new customers

Which competitiveness indicator do you consider more influential?	C1.1	C1.2			
To what extent?	1	3	5	7	9

Figure 4. Sample of questionnaire used for comparison of alternatives.

Table 2. Original supermatrix.

		A	B	C	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3	4.4.
A	Company A	0	0	0	0.429	0.127	0.785	0.348	0.733	0.761	0.081	0.229	0.200	0.761	0.669	0.225	0.100	0.744	0.243	0.487	0.127
B	Company B	0	0	0	0.429	0.687	0.149	0.582	0.068	0.073	0.342	0.075	0.400	0.166	0.088	0.610	0.680	0.192	0.669	0.078	0.687
C	Company C	0	0	0	0.143	0.186	0.066	0.069	0.199	0.166	0.577	0.696	0.400	0.073	0.243	0.166	0.220	0.064	0.088	0.435	0.186
1.1	Delivery Time	0	0	0	0.000	1.000	0.000	1.000	0.000	1.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.2	Maintaining Customers	0	0	0	0.000	0.000	0.167	0.000	0.000	0.000	0.000	0.750	0.000	0.800	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.3	Market Share	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000	0.000	0.000
1.4	New Customers	0	0	0	0.000	0.000	0.833	0.000	0.000	0.000	0.000	0.250	0.000	0.200	0.000	0.000	0.000	0.000	0.000	0.000	1.000
2.1	Debt	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.260	0.000	0.000	0.000
2.2	Liquidity	0	0	0	0.000	0.000	0.000	0.000	0.174	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.085	0.000	0.000	0.000
2.3	Profitability	0	0	0	1.000	0.000	0.000	0.000	0.634	1.000	0.000	0.000	0.000	1.000	0.000	0.000	1.000	0.504	1.000	0.000	1.000
2.4	Sales new product	0	0	0	0.000	1.000	1.000	1.000	0.192	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000
3.1	Computing platform	0	0	0	0.167	0.167	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.109	0.341	0.000	0.000	0.000	0.000	0.000	0.000
3.2	New Sevices	0	0	0	0.000	0.833	0.750	1.000	0.000	0.196	0.000	1.000	0.500	0.000	0.148	0.250	0.174	0.000	0.000	0.000	0.800
3.3	Productivity	0	0	0	0.833	0.000	0.000	0.000	0.000	0.311	0.667	0.000	0.500	0.729	0.000	0.000	0.192	1.000	0.000	1.000	0.200
3.4	RM Waste	0	0	0	0.000	0.000	0.000	0.000	0.000	0.493	0.333	0.000	0.000	0.000	0.443	0.000	0.634	0.000	0.000	0.000	0.000
3.5	Social enviroment	0	0	0	0.000	0.000	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.163	0.069	0.750	0.000	0.000	0.000	0.000	0.000
4.1	Innovation	0	0	0	0.140	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.800	0.250	0.196	0.000	1.000	0.000	0.072	0.667	1.000
4.2	Maintaining workers	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.3	Strategy decision making	0	0	0	0.333	0.167	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.493	0.000	0.000	0.000	0.476	0.000	0.000
4.4.	Training level workers	0	0	0	0.528	0.833	0.000	1.000	0.000	0.000	0.000	1.000	0.200	0.750	0.311	1.000	0.000	0.000	0.452	0.333	0.000

Analysis and discussion

Based on the results, the CCI values of the companies were reviewed in order to define improvement action plans. In particular, Company B, placed in the third position, had the lowest index value of the three. Therefore the improvement plans for Company B should address the development of strategies that allow it to increase productivity, innovation capability and the sales of new products.

In general, for these three companies of the plastic industrial sector, the improvement plans should address product innovation, process improvement, training plans for workers and increased sales of new products. Additionally, the organisations should innovate not only in products but also in services to customers, as this will allow them to maintain their customer portfolio and to increase their participation in the market. Moreover, they should not forget business sustainability through profitability.

Table 3. Results obtained and normalisized from the limit matrix.

Company A	0.4387
Company B	0.2675
Company C	0.2936
C1.1 Participation in the market	0.0531
C1.2 Rate of new customers	0.0489
C1.3 Maintaining customers	0.0668
C1.4 Delivery time	0.0362
C2.1 Maintaining workers	0
C2.2 Training level of the workers	0.1143
C2.3 Strategic decision making	0.0374
C2.4 Innovation capability	0.1219
C3.1 Computation and systems	0.0241
C3.2 RM waste rate	0.0304
C3.3 Productivity	0.1248
C3.4 New services	0.0875
C4.1 Liquidity	0.0021
C4.2 Profitability	0.0595
C4.3 Debt	0.0042
C4.4 Sales of new products	0.1252

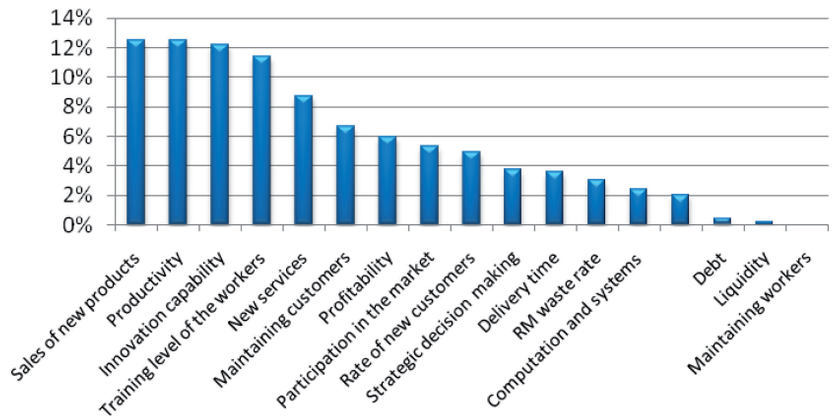


Figure 5. Weights of the competitiveness indicators, combined model.

Finally, a satisfaction survey based on Smith-Perera *et al*. (2010) was conducted on the experts. Based on the results of this survey we can conclude that the method proposed in this paper is useful and seems sufficiently rigorous and precise. The experts found the results obtained coherent.

The survey is shown in Appendix. The scale used was 1 (lowest) to 5 (highest). The results of the survey indicate that the experts are satisfied with the results, giving a score of 4, the process efficiency was rated with a score of 4.5 and its difficultly level was given a score of 2. Finally, the probability that they will use this method in the future was given a score of 3.5.

6. Conclusions

The present work describes a new approach, based on ANP, to assess companies' competitiveness performance in an efficient and reliable way. It includes an indicator selection process adapted to the particular industrial sector under analysis. The approach combines the use of the analytic network process (ANP) method with the balanced scorecard to achieve competitiveness indicators. The use of ANP can be justified by its ability to obtain quantitative values

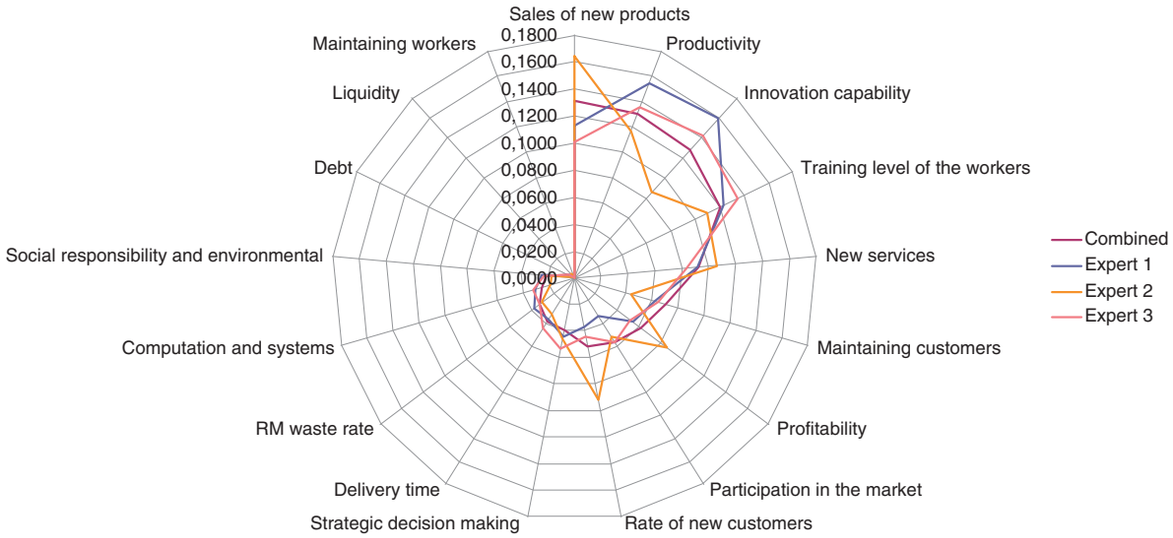
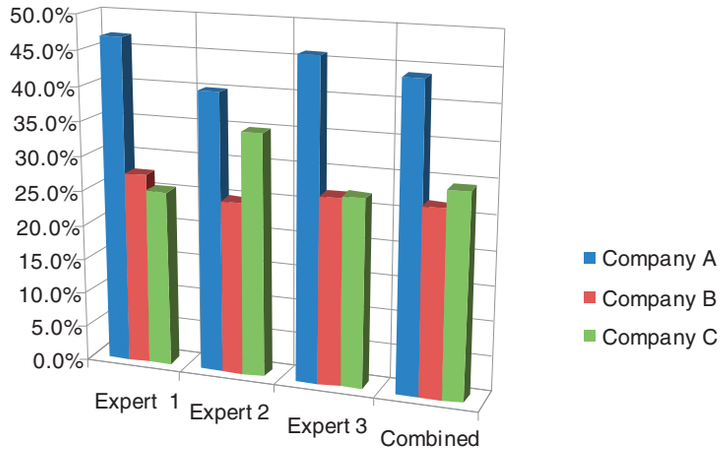


Figure 6. Analysis of the alignment of the results obtained for the competitiveness indicators.



	Expert 1	Expert 2	Expert 3	Combined
Company A	46.8%	40.1%	45.9%	43.90%
Company B	27.7%	24.9%	26.9%	26.80%
Company C	25.4%	34.9%	27.2%	29.40%

Figure 7. Comparison of company prioritisation provided by experts.

390 from experts' qualitative judgments and also because it enables the aggregation of the selected experts' judgments. The experts were chosen according to their experience and knowledge of the industrial sector analysed.

Porter's BSC paradigm facilitates the understanding of competitiveness as a whole. The analysis of the value chain of companies with similar characteristics in the same sector helps to identify early indicators of competitiveness, which will then be prioritised to the implementation of ANP. For its validation, the methodology
395 was applied to the plastic industrial sector of Venezuela.

The criteria (indicators) weighting provides some important insights into the overall philosophy and underlying expert conception of what competitiveness in the plastic sector is. The resulting data for the indicators show that

sales of new products, productivity and innovation capability are the most important indicators to consider when analysing competitiveness in the plastic sector.

The results obtained by the companies for all the different indicators analysed allow them to diagnose their behaviour from the point of view of competitiveness and propose innovative improvement plans aligned with these indicators.

Regarding the results obtained by the three companies, the CCI value each of them obtained, they showed how good their competitiveness degree was with respect to other companies in the same sector. It allowed them to compare themselves. They used this data to review their situation and to state well-defined improvement actions. The experts' opinions coincided in the selection of most indicators but not in the weights allocated to the indicators. Similarly they did not coincide in the prioritisation of the companies through the CCI obtained. But all three agreed with the final results and the procedure followed. The case study evidenced that the geometric mean proposed by ANP to aggregate judgments contributes to balance extreme positions among the decision-making agents. The experts also showed agreement and satisfaction with the process and the results, though indicated that it was complex and hard, particularly categorising the influences among the competitiveness indicators of the case study.

Based on the review of the literature and the findings of the present study, we can conclude that it is not so important for an organisation to measure all areas in a competitiveness system since it may become a cumbersome and complex process. By contrast, it is relevant for any organisation to have clear goals as well as the metrics and corresponding weights that directly contribute to reaching these goals. The ANP model efficiently contributes to defining the necessary indicators.

Although the methodology satisfied the experts as well as the decision makers, the ANP procedure was not free of criticism. During the ANP application to the case study, some difficulties were observed, such as the fact that ANP prescribes comparisons that can occasionally be complex to understand for experts not familiar with the method. Hence, much attention must be devoted to the design of the questionnaires and the comparison process must be carried out with the help of a facilitator. Despite these difficulties, the results obtained in this work allow us to conclude that ANP is a suitable tool for assessing the competitive performance of companies. Although the new proposal has been specifically applied to the plastic sector, this tool can be adapted to any industrial sector, provided the criteria are correctly identified and there are some dependencies among them. This tool constitutes a very promising future research line in the field of competitiveness measurement systems.

It is envisaged to continue with this research focusing on other industrial sectors in Venezuela: advertising, meat and dairy. For each one of them, the experts will have to define their own business model adjusted to the characteristics of the sector and help to solve the ANP model. The aim will be to find a dominance within indicators across sectors.

References

Aragonés-Beltrán, P., *et al*., 2008. Valuation of urban industrial land: An analytic network Process approach. *European Journal of Operational Research*, 185 (1), 322–339.

Augusto, M., *et al*., 2006. Benchmarking in a multiple criteria performance context: An application and a conceptual framework. *European Journal of Operational Research*, 184 (▮), 244–254.

AVIPLA, 2008. *Presentación del sector plástico*. Asociación Venezolana de Industrias Plásticas.

Barba-Romero, S. and Pomerol, J., 1997. *Decisiones Multicriterio Fundamentos teóricos y Utilización Práctica*. ▮: Colección de economía Universidad de Alcalá.

Belton, V. and Stewart, T., 2002. *Multiple criteria decision analysis*. Kumer Academy Publishers.

Ellis, S., Elnatha, D., and Raz, T., 2002. Applying benchmarking: An organizational learning perspective. *Human System Management*, 21 (▮), 183–191.

Fernández, M., 2004. Factores contextuales que explican el éxito de las pymes del sector plástico en Venezuela. Available from: http://www.gestiopolis.com/Canales4/emp/factontextu.htm [Accessed 20 February 2008].

Grigoroudis, E., Orfanoudakia, E., and Zopounidisa, C., 2011. Strategic performance measurement in a healthcare organisation: A multiple criteria approach based on balanced scorecard. *Omega* (in press). Available from: http://www.sciencedirect.com/science/article/pii/S0305048311000612 [Accessed 10 March 2011].

Gunasekaran, A. and Kobu, B., 2007. Performance measures and metrics in logistics and supply chain management: A review of recent literature (1995–2004) for research and applications. *International Journal of Production Research*, 45 (12), 2819–2840.

Hsu, C-W., *et al*., 2011. Using the FDM and ANP to construct a sustainability balanced scorecard for the semiconductor industry. *Expert Systems with Applications*, 38 (10), 12891–12899.

Hult, G., Snow, Ch., and Kandermir, D., 2003. The role of entrepreneurship in building cultural competitiveness in different organizational types. *Journal of Management*, 29 (3), 401–426.

Jalali Naini, S.G., Aliahmadia, A.R., and Jafari-Eskandaria, M., 2010. Designing a mixed performance measurement system for environmental supply chain management using evolutionary game theory and balanced scorecard: A case study of an auto industry supply chain. *Resources, Conservation and Recycling*, 55 (6), 593–603.

Kaplan, R y Norton, 2000. *Cuadro de Mando Integral*. Barcelona, Ediciones Gestión, S.A.

Keeney, R.L. and Raiffa, H., 1976. *Decisions with multiple objectives: Preferences and value tradeoffs*. New York: John Wiley.

Lee, A., Chen, W-C., and Chang, C-J., 2008. A fuzzy AHP and BSC approach for evaluating performance of IT department in the manufacturing industry in Taiwan. *Expert Systems with Applications*, 34 (▮), 96–107.

Lee, A.H.I., Chen, H.H., and Tong, Y., 2007. Developing new products in a network with efficiency and innovation. *International Journal of Production Research*, iFirst, 1–21.

Leung, L.C., Lam, K.C., and Cao, D., 2006. Implementing the balanced scorecard using the analytic hierarchy process and the analytic network process. *The Journal of the Operational Research Society*, 57 (6), 682–691.

Liedtka, S., 2005. Analytic hierarchy process and multi-criteria performance management systems. *Cost Management*, 19 (6), 30–38.

Lin, Y-H., *et al*., 2009. Research on using ANP to establish a performance assessment model for business intelligence systems. *Expert Systems with Applications*, 36 (2), 4135–4146.

Öztayşi, B., Kaya, T., and Kahraman, C., 2011. Performance comparison based on customer relationship management using analytic network process. *Expert Systems with Applications*, 38 (8), 9788–9798.

Öztayşi, B. and Uçal, Ĭ., 2009. Comparing MADM techniques for use in performance measurement. *In*: *Proceedings of the international symposium on the analytic hierarchy process*. Pittsburgh, PA, USA.

Porter, M., 1995. *Ventaja Competitiva*. Buenos Aires: Cecsa.

Porter, M., 1997. *Estrategia Competitiva*. México: Cecsa.

Raisinghani, H.S., Meade, L., and Schkade, L., 2007. Strategic e-business decision analysis using analytic network process. *IEEE transactions on Engineering Management*, 54 (4), 673–686.

Reisinger, H., Cravens, K., and Tell, N., 2003. Prioritizing performance measures within the balanced scorecard framework. *Management International Review*, 43 (4), 429–437.

Roy, B., 1996. *Multicriteria methodology for decision aiding*. ▮: Kluwer Academic.

Saaty, T.L., 1980. *The analytic hierarchy process*. New York: McGraw-Hill.

Saaty, T.L., 1996. *The analytic hierarchy process: Planning, priority setting, resource allocation*. Pittsburgh: RWS Publications.

Saaty, T., 2000. *Fundamentals of decision making and priority theory with the analytic hierarchy process*. Pittsburgh: RWS Publications.

Saaty, T., 2005. *Theory and applications of the analytic network process*. Pittsburgh: RWS Publications.

Shahin, A. and Mahbod, M.A., 2007. Prioritization of key performance indicators: An integration of analytical hierarchy process and goal setting. *International Journal of Productivity and Performance Management*, 56 (▮), 226–240.

Sirikrai, S. and Tang, J., 2006. Industrial competitiveness analysis: Using the analytic hierarchy process. *Journal of High Technology Management Research*, 17 (▮), 71–83.

Smith-Perera, A., *et al*., 2010. A project strategic index proposal for portfolio selection in electrical company based on the analytic network process. *Renewable and Sustainable Energy Reviews*, 14 (▮), 1569–1579.

Spendolini, M., 1994. *Benchmarking*. Editorial Norma. Traducido al español por Carlos Fernando Villa, Colombia.

Superdecisions, 2009. Creative decision foundation. Available from: http://www.superdecisions.com [Accessed 1 April 2010].

Temur, G., Emeksizoglu, B., and Gozlu, S., 2007. A Study on performance measurement of a plastic packaging organization's manufacturing system by AHP modeling. *In*: *PICMET 2007 proceeding*, 5–9 August, Portland, Oregon.

Thakkar, J., *et al*., 2007. Development of a balanced scorecard. An integrated approach of interpretative structural modeling (ISM) and analytic network process (ANP). *International Journal of Productivity and Performance Management*, 56 (1), 25–59.

Tseng, M-L., 2010. Implementation and performance evaluation using the fuzzy network balanced scorecard. *Computers and Education*, 55 (▮), 188–201.

Yang, C-L., Chuang, S-P., and Huang, R-H., 2009. Manufacturing evaluation system based on AHP/ANP approach for wafer fabricating industry. *Expert Systems with Applications*, 36 (8), 11369–11377.

Yüksel, I. and Dagdeviren, M., 2010. Using the fuzzy analytic network process (ANP) for balanced scorecard (BSC): A case study for manufacturing firm. *Expert Systems with Applications*, 37 (▮), 1270–1278.

Appendix: Satisfaction survey conducted on experts.

In your opinion, the results obtained with the methodology with respect to what you expected are:				
1. Very unsatisfactory	2. Unsatisfactory	3. Somehow satisfactory	4. Satisfactory	5. Very satisfactory
In your opinion, the decision-making process used was:				
1. Very inefficient	2. Inefficient	3. Somehow efficient	4. Efficient	5. Very efficient
In your opinion, the process was:				
1. Very difficult	2. Difficult	3. Normal	4. Easy	5. Very easy
Would you use this methodology in the future?				
1. Never	2. Maybe	3. Possibly	4. Most probably	5. Certainly