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A proactive balanced scorecard

Panagiotis Chytas[a], Michael Glykas[b,*], George Valiris[a]

[a] University of Aegean, Department of Business Administration, 8 Michalon Street, Chios 82 100, Greece
[b] University of Aegean, Department of Financial and Management Engineering, Kountouriotou Street, Chios 82 100, Greece

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ABSTRACT

This paper describes a methodology for the development of a proactive balanced scorecard (PBSCM). The balanced scorecard is one of the most popular approaches developed in the field of performance measurement. However, in spite of its reputation, there are issues that require further research. The present research addresses the problems of the balanced scorecard by utilizing the soft computing characteristics of fuzzy cognitive maps (FCMs). By using FCMs, the proposed methodology generates a dynamic network of interconnected key performance indicators (KPIs), simulates each KPI with imprecise relationships and quantifies the impact of each KPI to other KPIs in order to adjust targets of performance.

1. Introduction

Today, companies are evolving in turbulent and equivocal environments (Drucker, 1993; Grove, 1999; Kelly, 1998). This requires companies to be alert and watchful so as to detect weaknesses (Ansoff, 1975) and discontinuities in regard to emerging threats and opportunities and to initiate further probing based on such detections (Glykas, 2004). The strategic role of performance measurement systems has been widely stressed in management literature. These systems provide managers with useful tools to understand how well their organisation is performing and to assist them in deciding what they should do next (Neely, 1998; Glykas & Valiris, 1999).

Performance measurement systems have grown in use and popularity over the last twenty years. Organisations adopted performance measurement systems for a variety of reasons, but mainly to achieve control over the organisation in ways that traditional accounting systems do not permit (Kellen, 2003). A review of the literature shows that traditional performance measurement systems (based on financial measures) have failed to identify and integrate all those factors that are critical in contributing to business excellence (Eccles, 1991; Fisher, 1992; Hayes, Wheelwright, & Clark, 1988; Kaplan, 1983, 1984; Maskell, 1992).

During the last decade, a number of frameworks, that help in designing and implementing performance measurement systems, has been identified in the literature, such as the balanced scorecard (Kaplan & Norton, 1992), the performance prism (Kennerley & Neely, 2000), the performance measurement matrix (Keegan, Eiler, & Jones 1989), the results and determinants framework (Fitzgerald et al., 1991), and the SMART pyramid (Lynch & Cross, 1991). These frameworks aim to assist organisations in defining a set of measures that reflects their objectives and assesses their performance appropriately. The frameworks are multidimensional, explicitly balancing financial and non-financial measures (Kennerley & Neely, 2002). Furthermore, a number of researchers have proposed a wide range of criteria for designing performance measurement systems (Globerson, 1985; Maskell, 1992; Morris, 2002).

Despite, the existence of numerous approaches (frameworks, criteria, etc.) it is evident, from the literature, that the need for a broader research in the field of performance measurement is required. The criticism about the *static* nature of performance measurement systems as well as the *relationships* and *trade-offs* that exist among different measures is the catalyst for this research. Furthermore, the software applications that have been developed so far lack of an analytic capability and they cannot do *predictive modelling* (Morris, 2002). Despite the many attempts in this area (EIS, decision support tools), it is claiming that these tools do not necessarily advance the decision-making process.

The main objective of this research is to propose a methodology (not a new performance measurement framework) that will support existing measurement framework(s) during the process of performance measurement systems' design, implementation and use, and to advance the decision-making process. Conforming to the most favoured approach, we have adopted the balanced scorecard, to explore the existence of *trade-offs* among measures within the *dynamic* nature of performance measurement systems that provide *predictive modelling* capabilities. The use of FCMs in the development of a Balanced Scorecard, will allow prospective decision-makers to incorporate their insights into the model. They may select the most preferable measures, add new ones, test the relationships between them, and visualise holistic outcomes.

* Corresponding author.
E-mail addresses: p.chytas@chios.aegean.gr (P. Chytas), mglikas@aegean.gr (M. Glykas), gval@aegean.gr (G. Valiris).

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This paper consists of five sections. Section 2 provides a literature review and research background; Section 3 presents the proposed methodology. Section 4 discusses the applicability of the proposed methodology. Finally, Section 5 concludes this paper.

2. Literature review

Senge (1992) argues that, in today's complex business world, organisations must be able to learn how to cope with continuous change in order to be successful. In this changing environment, the need for adequate design, implementation and use of performance measurement systems, is greater than ever. Eccles (1991) claims that it will become increasingly necessary for all major businesses to evaluate and modify their performance measures in order to adapt to the rapidly changing and highly competitive business environment.

The introduction of a performance measurement system is based on a three-stage process: design, implementation and use. Failing to implement any of these stages will result into a non-robust performance measurement system. When attempting to improve organisational performance by utilising performance measurement systems a critical point is the selection of appropriate measures. Anticipating this, several approaches have been introduced (frameworks, criteria, etc.). However, in spite the availability of such approaches, the need to further research the area of performance measurement is necessary.

Several authors have recognised that much more has to be done in order to identify the relationships among measures (Bititci and Turner, 2000; Flapper, Fortuin, & Stoop, 1996; Neely, 1999). Kaplan, when interviewed by de Waal (de Waal, 2003), argued that cause-and-effect relationships should be tested further. Nevertheless, in almost all cases, organisations ignore the dynamic interdependencies and trade-offs among measures. Furthermore, criticism exists regarding performance measurement systems and their static nature. According to Kennerley and Neely (2002), consideration is being given to what should be measured today, but little attention is being paid to the question of what should be measured tomorrow. They suggest that measurement systems should be dynamic and must be modified as circumstances change. A radical rethink of performance measurement is now necessary more than ever (Corrigan, 1998; Takikonda & Takikonda, 1998). In an attempt to describe and test cause-and-effect relationships, Kaplan and Norton (2001) proposed the use of strategy maps. However, the causal relationships that strategy maps claim to model are not always linear and one-way (Kaplan and Norton refer only to linear and one-way cause and effect chain), but mostly a fuzzy mess of interactions and interdependencies.

Kellen (2003) argues that in the area of executive management only 6 in 10 executives place confidence in the data presented to them. He points out that one of the main factors that prevent measurement is the fuzzy objectives. By the same token, Xirogiannis, Chytas, Glykas, and Valiris (2008) explains that in a performance measurement system a large number of multidimensional factors can affect performance. Integrating those multidimensional effects into a single unit can only be done through subjective, individual or group judgement. It is impossible to have an objective measurement and scale system for each different dimension of measurement that can facilitate objective value trade-off between different measures. They argue that techniques, which are suited to fuzzy paradigms, should be considered.

Identifying the relationships and trade-offs that exist among measures will be a great step towards the design of a robust performance measurement system. However, the robustness of the performance measurement system is also based on its successful implementation and use. According to Neely et al. (2000), implementation is not a straightforward task due to fear/resistance, politics and subversion. Dumond (1994) claims that the main problems in the implementation of performance measurement systems are raised due to the lack of communication and dissemination of performance information. According to De Geus (1994) even a simplified but credible (causal) model can be a powerful communication and learning tool. In the same token, Morecroft (1994) argues that models are more effective when they become integral parts of management debate, communication, dialogue and experimentation. It is possible for managers to gain insights about how their actions might affect outcomes if they work with models. Furthermore, experimentation with models creates a cycle of increased learning and improved models.

Finally, further to all the aforementioned issues, Morris (2002) argues that software applications that have been developed so far, lack of an analytic capability and they cannot carry out predictive modelling. Despite the many attempts in this area (EIS, Decision Support tools), it is claimed that these tools do not necessarily advance the decision-making process.

2.1. Balanced scorecard

According to Kaplan and Norton (1996a), the balanced scorecard supplements traditional financial measures with criteria that measure performance from three additional perspectives—those of customers, internal business processes, and learning and growth (Fig. 1).

- Customer perspective
  Since companies create value through customers, understanding how they view performance becomes a major aspect of performance measurement.
- Internal business process perspective
  According to Kaplan and Norton (2000), in the internal-business-process perspective, executives identify the critical internal processes in which the organisation must excel.
- Learning and growth perspective
  According to Kaplan and Norton (2000), this perspective of the balanced scorecard identifies the infrastructure that the organisation must build to create long-term growth and improvement. Learning and growth come from three principal sources: 1. People; 2. Systems; and 3. Organisational procedures.
- Financial perspective
  Within the balanced scorecard, financial measures remain an important dimension. Financial performance measures indicate whether a company's strategy, implementation, and execution are contributing to bottom-line improvement.
- Limitations of the balanced scorecard
  Balanced scorecard (Kaplan & Norton, 1992), briefly described previously, is the most popular framework in the area of performance measurement. The introduction of the balanced scorecard was mainly based on a transition from the traditional financial performance measurement systems towards a more balanced approach (financial and non-financial measures) that includes several measures in a multi-dimensional structure. In spite of its "reputation", there are several issues related to the balanced scorecard, which need further research. More particularly:

- Cause and effect consider to be one-way in nature
  The cause and effect concept is a very important element to consider in an attempt to construct a Balanced Scorecard. However, the way cause and effect is illustrated is rather problematic. Measures in the balanced scorecard are placed in a cause and effect chain rather a systemic approach. Kaplan and Norton (1996b) argue that '*the financial objectives serve as the focus for the objectives and measures in all the other scorecard perspectives*'.

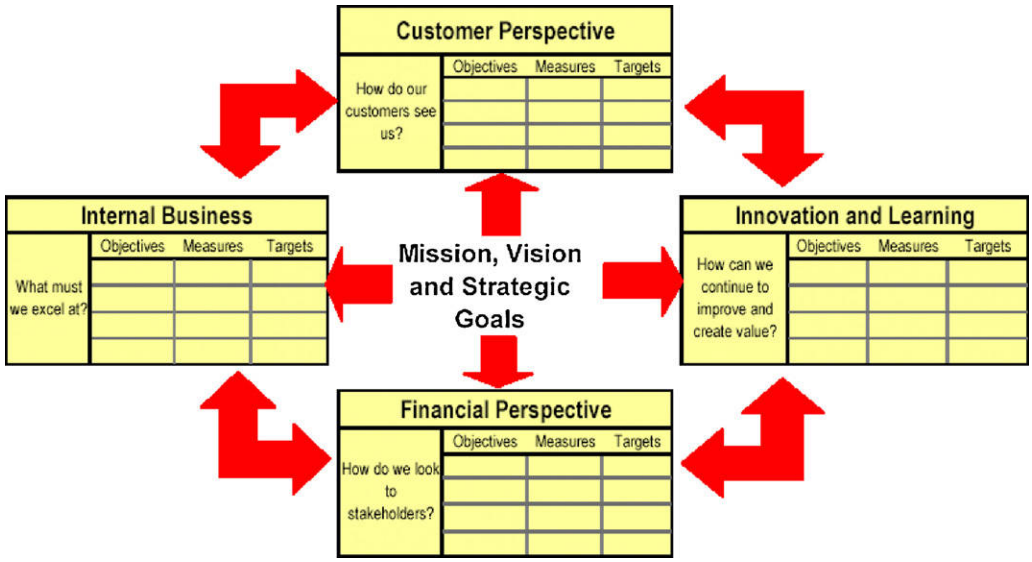

Fig. 1. The balanced scorecard.

This statement ignores any feedback loops that might exist.

- Trade-offs among measures and among the four perspectives are ignored

  Ignoring the trade-offs among measures as well as among the four perspectives is rather not an efficient approach. By doing so, the *communication of strategy* and *dissemination of performance information* is restricted because users are not in position to identify and learn why and how certain things have occurred.

- Measures are equally weighted

  All the measures in balanced scorecard are given the same weighting. This is not what happens in reality. Some measures may be more important and have greater impact compared to others. Weighting the measures among each other is critical on decision-making.

- Design techniques used for the development of a balanced scorecard are rather poor in illustrating the dynamics of a system (absence of feedback loops)

  Two of the most usual design techniques used for the development of the balanced scorecard are the bubble diagram and the generic value chain model (Fig. 2(a) and (b)). Recently Kaplan and Norton (2001) introduced a new model; the strategy maps (Fig. 2(c)). However, as it has been observed, these models lack the ability of representing feedback loops. This is not very suitable for communicating strategy as well as exploring the interrelationships among measures and in turn objectives. Ignoring the feedback loops (two-way cause and effect) at the design stage of a performance measurement system will lead to a non-effective representation of the organisation and the dynamics that are involved. Introducing new measures in this way restricts the possibility to identify the consequences that might be raised in the whole system.

2.2. A fuzzy logic view—FCMs

Fuzzy logic was introduced in 1965 by Zadeh as a means of representing data and manipulating data that was not precise, but rather fuzzy. The theory of fuzzy logic provides a mathematical strength to capture the uncertainties associated with human cognitive processes, such as thinking and reasoning. Since its first appearance, fuzzy logic has been used in a variety of applications, such as image detection of edges, signal estimation, classification and clustering. A fuzzy logic technique represents an alternative solution to the design of intelligent engineering systems. Thus, fuzzy rule-based experts systems are widely applied nowadays, this being supported by the fact that fuzzy logic is linguistic rather than numerical, something which makes it similar to human thinking and hence simpler to understand and put into practice. It is not within the scope of this paper to present an overview of fuzzy logic and the reader is directed to the seminal work on the subject by Zadeh (1997) and in the more recent non-mathematical text by Kosko (1998). In this paper, the concept of an FCM is used to define the state of a set of variables/objectives.

FCMs are soft computing tools which combine elements of fuzzy logic and neural networks. They are fuzzy signed directed graphs with feedback loops, in which the set of concepts (each concept represents a characteristic, state or variable of the system/model; concepts stand for events, actions, goals, values and/or trends of the system being modelled as an FCM), and the set of causal relationships is modelled by directed arcs (Fig. 3). FCM theory developed recently (Kosko, 1986) as an expansion of cognitive maps that had been employed to represent social scientific knowledge (Axelrod, 1976), to make decision analysis (Zhang, Chen, & Bezdek, 1989) and to analyse extend-graph theoretic behaviour (Zhang & Chen, 1988).

Fig. 3 illustrates an FCM which is used to simulate the behaviour of *Company Profitability* in terms of other factors that positively or negatively affect its state (behaviour). In the figure above, *Company Profitability* is directly affected by the following factors: *Customer Satisfaction* (positive effect), *Sales Volume* (positive effect) and *Internal Cost* (negative effect). Directed, signed and weighted arcs, which represent the causal relationships that exist between the concepts, interconnect the FCM concepts. For example, in Fig. 3, there is a strong positive relationship from the *Customer Satisfaction* concept to the *Company Profitability* concept. Each concept is characterised by a numeric value that represents a quantitative measure of the concept's presence in the model. A high numeric value indicates the strong presence of a concept. The numeric value results from the transformation of the real value of the system's variable, for which this concept stands, to the interval [0,1]. All the values in the graph are fuzzy, so weights of the arcs are described with linguistic values (such as: "strong", "weak", etc.) that can be "defuzzified" and transformed to the interval [−1,1].

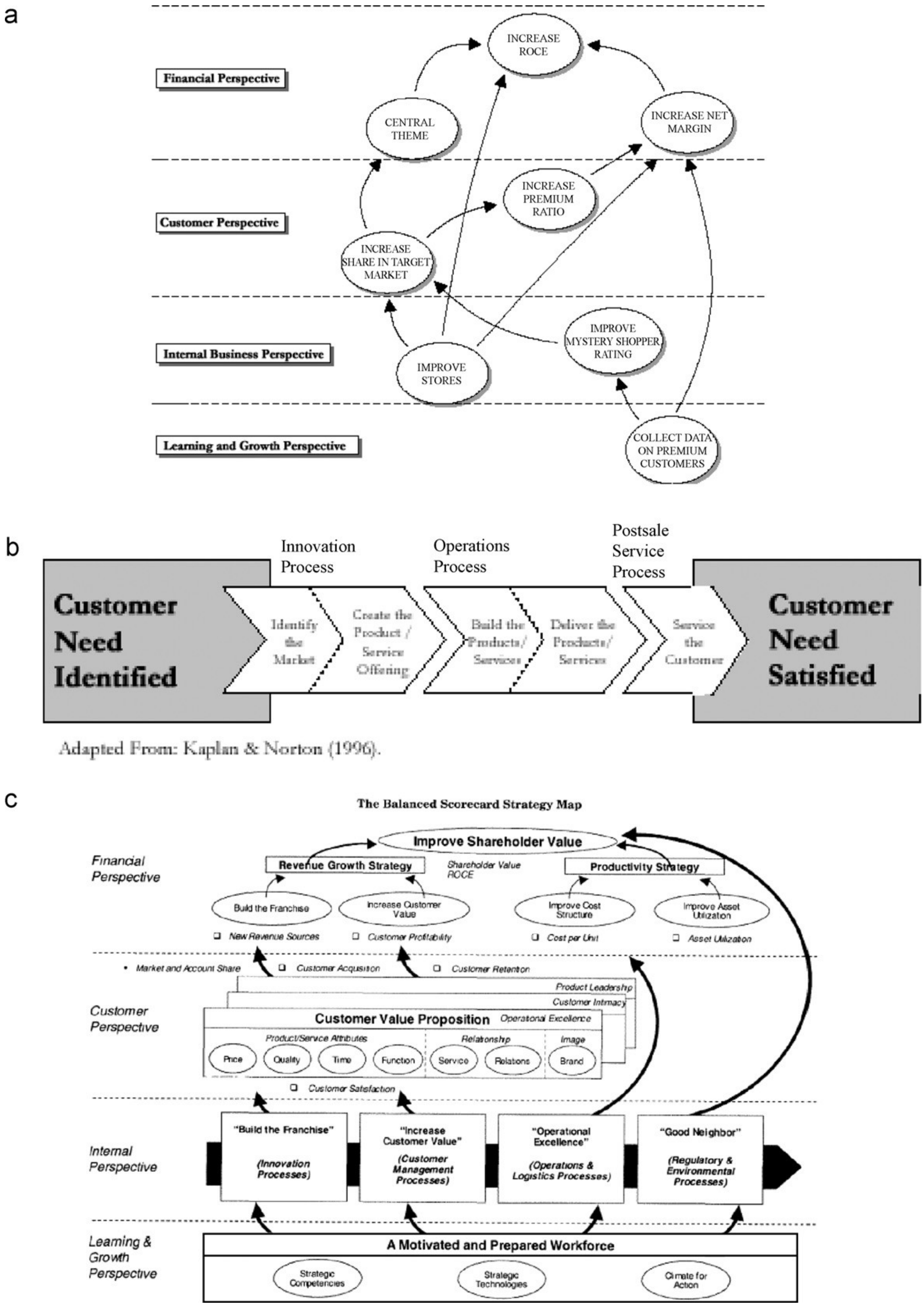

Fig. 2. Design techniques for the development of a balanced scorecard.

Studying this graphical representation, one can conclude which concept influences other concepts and their interconnections. This representation makes updating the graph structure easy, as new information becomes available or as more experts are asked. This can be done, for example, by the addition or deletion of an interconnection or a concept.

Between concepts, there are three possible types of causal relationships expressing the type of influence of one concept on another. The weight of an interconnection, W_{ij}, for the arc from concept C_i to concept C_j, can be positive ($W_{ij} > 0$), which means that an increase in the value of concept C_i leads to the increase of the value of concept C_j, and a decrease in the value of concept C_i leads to

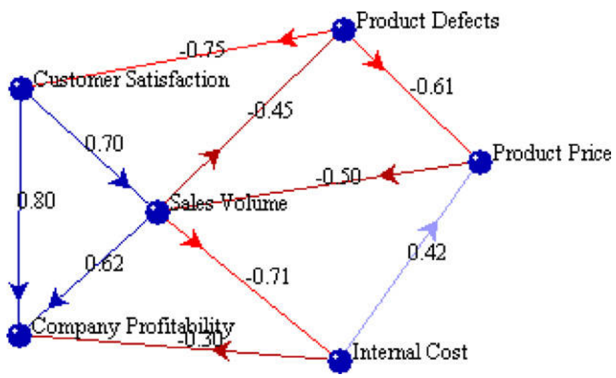

Fig. 3. A simple FCM.

the decrease of the value of concept C_j. Or there is a negative causality ($W_{ij} < 0$), which means that an increase of the value of concept C_i leads to the decrease of the value of concept C_j and vice versa. When there is no relationship from concept C_i to concept C_j, then ($W_{ij} = 0$). In Fig. 3, the weight of the interconnection between the concepts, *Company Profitability* and *Sales Volume* is positive (represented by a blue arc and a positive value) and is illustrated as follows: if *Sales Volume* is high then *Company profitability* will be high—if *Sales Volume* is low then *Company Profitability* will be low.

An expert defines the main concepts that represent the model of the system, based on his knowledge and experience on the operation of the system. At first, the expert determines the concepts that best describe the system. He knows which factors are crucial for the modelling of the system and he represents each one by a concept. Moreover, he has observed which elements of the system influence other elements and for the corresponding concepts he determines the positive, negative or zero effect of one concept on the others. He describes each interconnection with a linguistic value that represents the fuzzy degree of causality between concepts. The linguistic weights are transformed into numerical weights using the methodology proposed by (Glykas, 2010).

When the FCM starts to model the system, concepts take their initial values and then the system is simulated. At each step, the value of each concept is determined by the influence of the interconnected concepts on the corresponding weights:

$$a_i^{t+1} = f\left(\sum_{j=1, j\neq i}^{n} w_{ji} a_j^t\right) \tag{1}$$

where a_i^{t+1} is the value of concept C_i at step $t+1$, a_j^t the value of the interconnected concept C_j at step t, W_{ji} the weighted arc from concept C_j to C_i, and f a threshold function. Three threshold functions have been identified in the literature (Kosko, 1998) and are described below:

$$\begin{aligned}
&s_i(x_i) = 0, \quad x_i \le 0\\
&s_i(x_i) = -1, \quad x_i > 0\\
&\text{bivalent}\\
&s_i(x_i) = -1, \quad x_i \le -0.5\\
&s_i(x_i) = 0, \quad -0.5x_i < x_i < 0.5\\
&s_i(x_i) = 1, \quad x_i \ge 0.5\\
&\text{trivalent}\\
&s_i(x_i) = \frac{1}{1+e^{-cx_i}}\\
&\text{logistic signla}, \ c = 5
\end{aligned} \tag{2}$$

3. A proactive balanced scorecard methodology (PBSCM)

3.1. Successful execution of strategy: a new component

According to Kaplan and Norton (2004) successful execution of a strategy (Breakthrough Results) requires two components:

$$\begin{aligned}&\{\text{Breakthrough Results}\}\\ &\quad = \{\text{Describe the Strategy}\} + \{\text{Manage the Strategy}\}\end{aligned} \tag{3}$$

The philosophy of the two components is simple:

- You cannot manage (second component) what you cannot measure (first component).
- You cannot measure what you cannot describe (Breakthrough Results).

According to Kaplan and Norton (2004), their first book, *The Balanced Scorecard*, has addressed the first component by showing how to measure strategic objectives in multiple perspectives. It also presented the early ideas regarding the second component, how to manage the strategy. Their second book, *The Strategy-Focused Organisation*, has provided a more comprehensive approach for how to manage the strategy. It has also introduced strategy maps for the first component, how to describe the strategy. Their third book, Strategy Maps, goes into much more detail on this aspect, using linked objectives in strategy maps to describe and visualize the strategy. They rewrite the above "equation" as follows:

$$\begin{aligned}&\{\text{Breakthrough Results}\} = \{\text{Strategy Maps}\} \rightarrow [\textit{Describe}]\\ &\quad + \{\text{Balanced Scorecard}\} \rightarrow [\textit{Measure}] + \{\text{Strategy}\\ &\quad - \text{Focused Organisation}\} \rightarrow [\textit{Manage}]\end{aligned} \tag{4}$$

However, it is our belief that both Eqs. (2) and (3) omit an important component: Simulate the Strategy. Hence, we rewrote the Eq. (2) as follows:

$$\begin{aligned}&\{\text{Breakthrough Results}\} = \{\text{Simulate the Strategy}\}\\ &\quad + \{\text{Describe the Strategy}\} + \{\text{Manage the Strategy}\}\end{aligned} \tag{5}$$

By incorporating this new component (Simulate the Strategy) in the above "equation" we aim to overcome all the limitations identified in the literature review (in particularly in Section 2.2.1) and view performance measurement and in particularly the balanced scorecard within a systemic approach. In order to address this new component, we suggest the use of fuzzy cognitive maps (FCMs). As it was described previously, FCMs are fuzzy signed directed graphs with feedback loops, in which the set of objects is modelled by the nodes, and the set of causal relationships is modelled by directed arcs. The FCM theory, was developed recently (Kosko, 1986) as an expansion of the cognitive maps that had been employed to represent social scientific knowledge (Axelrod, 1976), to make decision analysis (Zhang et al., 1989) and to analyse extend-graph theoretic behaviour (Zhang & Chen, 1988). FCMs combine the strengths of cognitive maps with fuzzy logic. By representing human knowledge in a form more representative of natural human language than traditional concept mapping techniques, FCMs ease knowledge engineering and increase knowledge-source concurrence. The characteristics and the structure of FCMs allow us to re-write Eqs. (3) and (4) as follows:

$$\begin{aligned}&\{\text{Breakthrough Results}\} = \{\text{FCMs}\} \rightarrow [\textit{Simulate}]\\ &\quad + \{\text{FCMs}\} \rightarrow [\textit{Describe}] + \{\text{Balanced Scorecard}\} \rightarrow [\textit{Measure}]\\ &\quad + \{\text{Strategy-Focused Organisation}\} \rightarrow [\textit{Manage}]\end{aligned} \tag{6}$$

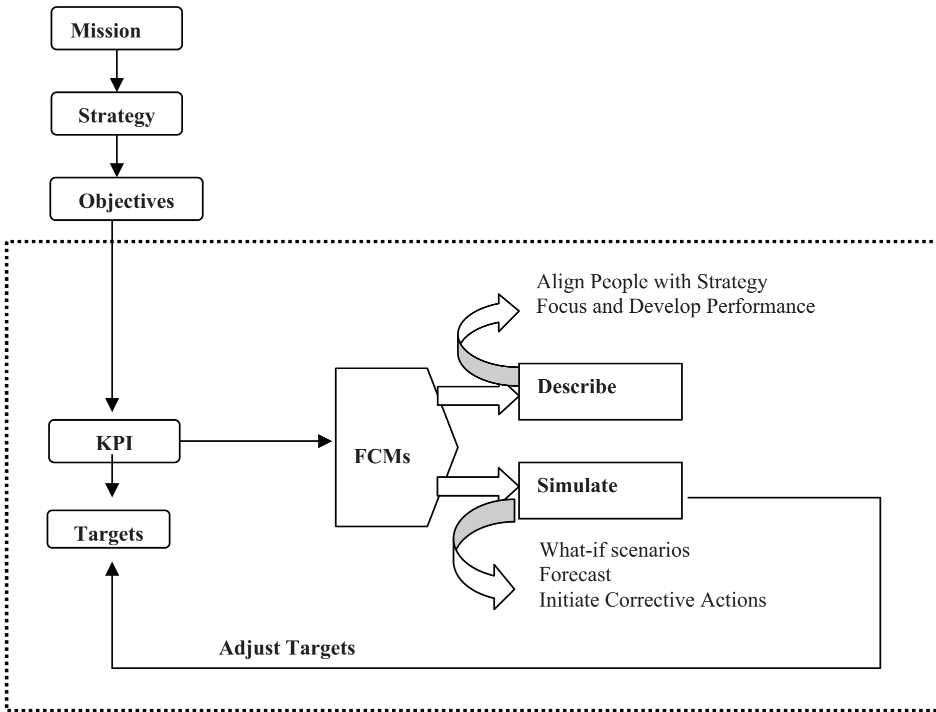

Fig. 4. The PBSCM.

In the above "equation", in the first instance (simulate), we use the simulation characteristics of the FCMs theory. The FCM approach involves forward-chaining (what-if analysis). The forward-chaining provides business domain experts with the capability to reason about the map they have constructed (nodes, relationships and weights) and examine different scenarios. In the second instance (describe), we utilise the representation capabilities of the FCMs theory. FCMs are illustrated as causal-loop diagrams. This is very suitable for communicating strategy as well as exploring the interrelationships among measures and in turn objectives.

3.2. Overview of the PBSCM

The methodology for the development of a proactive balanced scorecard is depicted in the figure below (Fig. 4). PBSCM is capable of illustrating non-linear interactions and feedback loops through the use of FCMs as a causal-loop diagram and performing what-if scenarios through the use of FCMs simulation.

The PBSCM goes through a series of stages that involve: (1) inputs to be provided, and (2) outcomes to be generated. Business domain experts and/or professionals of performance measurement/balanced scorecard are people with specific business expertise that contribute towards providing the business knowledge for the PBSCM. The following table (Table 1) indicates the stages of a PBSCM together with the inputs and outcomes of each stage.

Before proceeding to each of the aforementioned stages a kick-off meeting takes place between the domain experts. The aim of this meeting is for all participants to contribute towards:

- Establishing the PBSCM team.
- Clarifying the objectives of the team.
- Identifying the context of the PBSCM.
- Selecting the reference material to be used for the construction of the PBSCM.
- Anticipating possible user benefits.
- Preparing further actions for the participants.

Table 1
Inputs and outcomes of the PBSCM.

Stage	Input	Outcome
1. Establishing the mission, vision, strategic objectives, perspectives and critical success factors (CSF)	1. Interviews with middle and top management	1. Mission
	2. Internal company data	2. Vision 3. Strategic objectives 4. Perspectives 5. CSF
2. Identify key performance Indicators (KPI)	1. CSF	1. KPI in each perspective
3. Establish targets	1. KPI	1. Target for each KPI
4. Define relationships among the identified KPI	1. KPI	1. FCM with no weights
5. Assign linguistic variables to weights and concepts-(KPI)	1. FCM with no weights	1. Final FCM with weights and concept values
6. Continuous improvement	1. Final FCM	1. Adjust targets

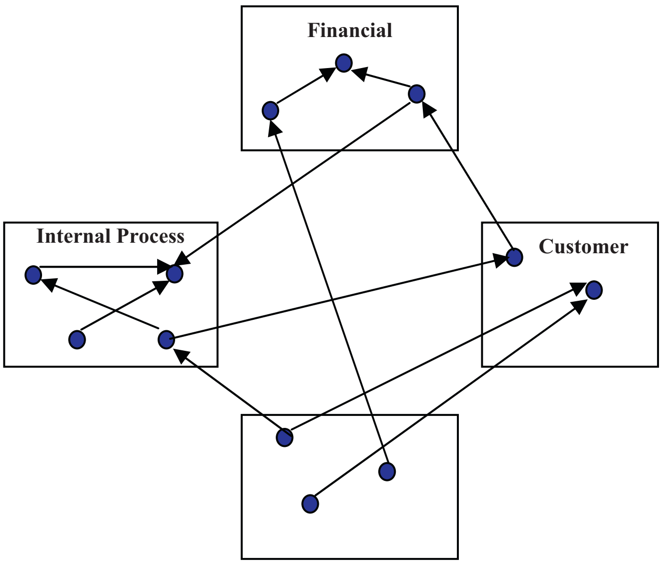

Fig. 5. Define relationships among the identified KPIs.

The PBSCM methodology is composed of the following stages:

1. Establishing the mission, vision, strategic objectives, perspectives and CSF
   In this stage the focus is on understanding the organisation's strategy, culture and capabilities in order to specify the strategic objectives (which state the specific goals/directions the organisation aims to achieve), perspectives and critical success factors (things the organisation must do well to achieve its strategic objectives).
2. Identify key performance indicators (KPI)
   This stage aims to narrow down the list of all possible measures into a shortest one that provides the KPIs, which will be used in each perspective.
3. Establish targets
   Measurement alone is not good enough. We must drive behavioural changes within the organisation if we expect to execute strategy. This requires establishing a target for each KPI within the balanced scorecard. Targets are designed to drive and push the organisation as to meet its strategic objectives. Targets need to be realistic so that people feel comfortable about trying to execute on the target.
4. Define relationships among the identified KPI
   As the KPIs constituting the different perspectives have been derived, the relationships between these KPIs (KPIs are represented as concepts in the FCM) have to be defined. An edge connecting two KPIs represents a relationship. The direction of the relationship (i.e. which KPI affects the other) is denoted by the direction of the arrow on this edge. The FCM that has been constructed (Fig. 5) using the method mentioned above does not contain any information except that there are relationships between abstract concepts (KPI). The next step is to enrich the map with numerical values, which are assigned to the concepts and relationships.
5. Assign linguistic variables to weights and concepts (KPI)
   Knowledge on the behaviour of a system is rather subjective and in order to construct a model of the system it is proposed to utilise the experience of experts. Experts are asked to describe the causality among concepts using linguistic notions (A fuzzy logic perspective). They will determine the influence of one concept to the other as "negative" or "positive" and then they will describe the grade of the influence with a linguistic variable such as "strong" and "weak". *Influence* of one concept over another, is interpreted as a linguistic variable in the interval [-1,1]. Its term set *T*(influence) is: *T*(influence) = {negatively very-very high, negatively very high, negatively high, negatively medium, negatively low, negatively very low, negatively very-very low, zero, positively very-very low, positively very low, positively low, positively medium, positively high, positively very high, positively very-very high}.
   We propose a semantic rule *M* to be defined at this point. The above-mentioned terms are characterized by the fuzzy sets whose membership functions μ are shown in Fig. 6.
   - *M*(negatively very-very high) = the fuzzy set for "an influence close to −90%" with membership function μ_{nvvh}.
   - *M*(negatively very high) = the fuzzy set for "an influence close to 80%" with membership function μ_{nvh}.
   - *M*(negatively high) = the fuzzy set for "an influence close to 65%" with membership function μ_{nh}.
   - *M*(negatively medium) = the fuzzy set for "an influence close to −50%" with membership function μ_{nm}.
   - *M*(negatively low) = the fuzzy set for "an influence close to −35%" with membership function μ_{nl}.
   - *M*(negatively very low) = the fuzzy set for "an influence close to −20%" with membership function μ_{nvl}.
   - *M*(negatively very-very low) = the fuzzy set for "an influence close to −10%" with membership function μ_{nvvl}.
   - *M*(zero) = the fuzzy set for "an influence close to 0" with membership function μ_{z}.
   - *M*(positively very-very low) = the fuzzy set for "an influence close to 10%" with membership function μ_{pvvl}.
   - *M*(positively very low) = the fuzzy set for "an influence close to 20%" with membership function μ_{pvl}.
   - *M*(positively low) = the fuzzy set for "an influence close to 35%" with membership function μ_{pl}.
   - *M*(positively medium) = the fuzzy set for "an influence close to 50%" with membership function μ_{pm}.
   - *M*(positively high) = the fuzzy set for "an influence close to 65%" with membership function μ_{ph}.
   - *M*(positively very high) = the fuzzy set for "an influence close to 80%" with membership function μ_{pvh}.
   - *M*(positively very-very high) = the fuzzy set for "an influence close to 90%" with membership function μ_{pvvh}.

   The membership functions are not of the same size since it is desirable to have finer distinction between grades in the lower and higher end of the influence scale. As an example, three experts propose different linguistic weights for the interconnection W_{ij} from concept C_i to concept C_j: (a) positively high, (b) positively very high, and (c) positively very-very high. The three suggested linguistics are integrated using a sum combination method and then the "defuzzification" method of the centre of gravity (CoG) is used to produce a weight W_{ij} = 0,73 in the interval [−1,1]. This approach has the advantage that experts do not have to assign numerical causality weights but to describe the degree of causality among concepts.
   A similar methodology can be used to assign values to concepts. The experts are also asked to describe the measurement of each concept using linguistic notions once again. Measurement of a concept is also interpreted as a linguistic variable with values in the interval [−1,1]. Its term set *T*(*Measurement*) = *T*(*Influence*). A new semantic rule *M*2 (analogous to *M*) is also defined and these terms are characterized by the fuzzy sets whose membership functions μ_2 are analogous to membership functions μ.
6. Continuous improvement
   The purpose of this phase is to continuously update the usability of the FCMs in order to provide improved user support. The continuous improvement cycle requires the users to run a

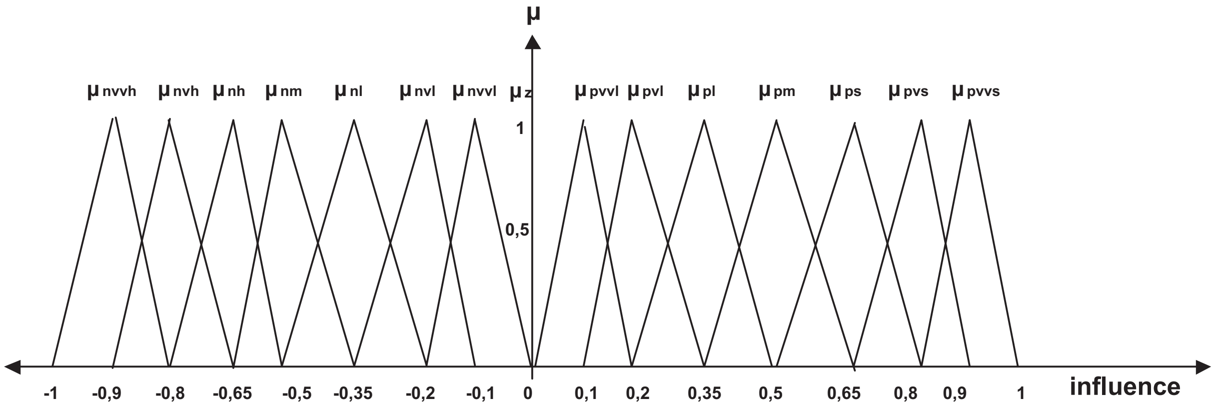

Fig. 6. Membership functions of linguistic variable influence.

simulation exercise on the FCM (using weight and concept values defined in the previous stage) and test its effectiveness in response to the targets defined previously. The adjustment will be based on the behaviour of the FCM during simulation and on the results it delivers.

4. Discussion

As far as the theoretical value is concerned, the PBSCM methodology extends previous research attempts by (a) allowing fuzzy definitions in the cognitive maps, (b) introducing a specific interpretation mechanism of linguistic variables to fuzzy sets, and (c) allowing dynamic decomposition and reconfiguration of a balanced scorecard strategy-map. As far as the practical value is concerned, preliminary evaluation results indicate that when compared to the expert estimates, the methodology provides reasonably good activities.

4.1. Added value

Having established the theoretical and practical value of the proposed methodology, it is useful to discuss also the added value of incorporating such a methodology during the development of the balanced scorecard. It is presumed in this paper that the resulting methodology provides real value to the principle beneficiaries and stakeholders of balanced scorecard projects. For example:

- The methodology eases significantly the complexity of deriving expert decisions concerning the balanced scorecard development.
- The proposed methodology serves as a back-end to provide holistic strategic performance evaluation and management.

4.2. Preliminary usability evaluation

Senior managers of two major IT enterprises have evaluated the usability of the proposed methodology and have identified a number of benefits that can be achieved by the utilization of the proposed mechanism as a methodology for balanced scorecard development. A summary of major business benefits (as identified by senior managers) is provided to improve the autonomy of this paper:

- *Shared goals*
  - ○ Concept-driven simulation pulls individuals together by providing a shared direction and determination for strategic change.
  - ○ Shared performance measurement enables business units to realize how they fit into the overall business model of the enterprise and what their actual contribution is.
  - ○ Senior management receives valuable input from the business units (or the individual employees) who really comprehend the weaknesses of the current strategic model as well as the opportunities for performance change.
- *Shared culture*
  - ○ All business units at the enterprise feel that their individual contribution is taken under consideration and provide valuable input.
  - ○ All business units and individuals at the enterprise feel confident and optimistic; they realize that they will be the ultimate beneficiaries of the balanced scorecard exercise.
  - ○ The information sharing culture supports the enterprise's competitive strategy and provides the energy to sustain this by exploiting group and individual potential to its fullest.
- *Shared learning*
  - ○ The enterprise realizes a high return on its commitment to human resources.
  - ○ There is a constant stream of improvement within the enterprise.
  - ○ The entire enterprise becomes increasingly receptive to strategic changes, since the benefits can be easily demonstrated to individual business units.
- *Shared information*
  - ○ All business units and individuals have the necessary information needed to set clear objectives and priorities.
  - ○ Senior management can effectively control all aspects of the strategic process
  - ○ The enterprise reacts rapidly to threats and opportunities.

5. Conclusions

This paper proposes a **p**roactive **b**alanced **sc**orecard **m**ethodology (**PBCSM**). The proposed decision aid may serve as a back end to Balanced Scorecard development and implementation. By using FCMs, the proposed methodology draws a causal representation of KPIs; it simulates the KPIs of each perspective with imprecise relationships and quantifies the impact of each KPI to other KPIs in order to adjust performance targets. The underlying research addressed the problems of the current balanced scorecard development process. The main objective of this research is to propose a methodology (not a new performance measurement framework) that will support existing measurement framework(s) during the process of performance measurement systems' design, implementation and use, and to advance the decision-making process. Future research will focus on conducting in depth studies to test and promote the usability of the methodology and to identify potential pitfalls.

References

Ansoff, H. I. (1975). Managing strategic surprise by response to weak signals. *California Management Review*, *XXVIII*(2), 21–33.

Axelrod, R. (1976). *Structure of decision: The cognitive maps of political elites*. Princeton, NJ: Princeton University Press.

Bititci, U. S., & Turner, T. (2000). Dynamics of performance measurement systems. *International Journal of Operations & Production Management*, *20*(6), 692–704.

Corrigan, J. (1998). Performance measurement: Knowing the dynamics. *Australian Accounting*, *68*(9), 30–31.

De Geus, A. (1994). *Modeling to predict or to learn?* Portland: Productivity Press.

de Waal, A. A. (2003). The future of the balanced scorecard: An interview with Professor Dr Robert S Kaplan. *Measuring Business Excellence*, *7*(1), 3.

Drucker, P. F. (1993). *Managing in turbulent times*. Harper Collins Publishers.

Dumond, E. J. (1994). Making best use of performance measures and information. *International Journal of Operations & Production Management*, *14*(9), 16–31.

Eccles, R. G. (1991). Performance measurement manifesto. *Harvard Business Review*, *69*(January–February), 131–137.

Fisher, J. (1992). Use of non-financial performance measures. *Journal of Cost Management*, *6*, 31–38.

Fitzgerald, L., Johnston, R., Brignall, S., Silvestro, R., & Voss, C. (1991). *Performance measurement in service businesses*. London: The Chartered Institute of Management Accountants.

Flapper, S. D., Fortuin, L., & Stoop, P. P. (1996). Towards consistent performance management systems. *International Journal of Operations & Production Management*, *16*(7), 27–37.

Globerson, S. (1985). Issues in developing a performance criteria system for an organisation. *International Journal of Production Research*, *23*(4), 639–646.

Glykas, M. (2004). Workflow and process management in printing and publishing firms. *International Journal of Information Management*, *24*(6), 523–538.

M. Glykas (Ed). Fuzzy Cognitive Maps: Advances in Tehories, Methodologies, Applications and Tools. ISBN: 3642032192, Springer, Germany, 2010.

Glykas, M., & Valiris, G. (1999). Formal methods in object oriented business modelling. *Journal of Systems and Software*, *48*(1), 27–41.

Grove, A. (1999). *Only the paranoid survive: How to exploit the crisis points that challenge every company*. Bantam Books.

Hayes, R. H., Wheelwright, S. C., & Clark, K. B. (1988). *Dynamic manufacturing: Creating the learning organization*. New York: Free Press.

Kaplan, R. S. (1983). Measuring manufacturing performance: A new challenge for managerial accounting research. *The Accounting Review*, *58*(4), 686–705.

Kaplan, R. S. (1984). Yesterday's accounting undermines production. *Harvard Business Review*, *62*(July–August), 95–101.

Kaplan, R. S., & Norton, D. P. (1992). The balanced scorecard—measures that drive performance. *Harvard Business Review*, *January–February*, 71–92.

Kaplan, R. S., & Norton, D. P. (1996a). Using the Balanced Scorecard as a Strategic Management System. *Harvard Business Review*, *January–February*.

Kaplan, R. S., & Norton, D. P. (1996b). *The balanced scorecard—translating strategy into action*. Boston, MA: Harvard Business School Press.

Kaplan, R. S. & Norton, D. P. (2000). *Why does business need a balanced scorecard?* http://www.corpfinance.riag.com/.

Kaplan, R. S., & Norton, D. P. (2001). Translating the balanced scorecard from performance measurement to strategic management: Part 1. *Accounting Horizons*, *15*(1), 87–104.

Kaplan, R. S., & Norton, D. P. (2004). *Strategy maps: Converting intangible assets into 19 tangible outcomes*. Boston, MA: Harvard Business School Press.

Keegan, D. P., Eiler, R. G., & Jones, C. R. (1989). Are your performance measures obsolete? *Management Accounting (US)*, *70*(12), 45–50.

Kellen, V. (2003). *Business performance measurement, at the crossroads of strategy, decision-making, learning and information visualization*. http://www.kellen.net/bpm.htm.

Kelly, K. (1998). *New rules for the new economy: Ten ways the network economy is changing everything*. London: Fourth Estate.

Kennerley, M. P., & Neely, A. D. (2000). Performance measurement frameworks—a review. In *Proceedings of the 2nd international conference on performance measurement* Cambridge,

Kennerley, M. P., & Neely, A. D. (2002). A framework of the factors affecting the evolution of performance measurement frameworks. *International Journal of Operations and Production Management*, *22*(11), 1222–1245.

Kosko, B. (1986). Fuzzy cognitive maps. *International Journal of Man-Machine Studies*, *24*, 65–75.

Kosko, B. (1998). Hidden patterns in combined and adaptive knowledge networks. *International Journal of Approximate Reasoning*, *2*, 377–393.

Lynch, R. L., & Cross, K. F. (1991). *Measure up—the essential guide to measuring business performance*. London: Mandarin.

Maskell, B. H. (1992). *Performance measurement for world class manufacturing: A model for American companies*. Cambridge: Productivity Press.

Morecroft, J. (1994). *Executive knowledge, models and learning*. Portland: Productivity Press.

Morris, H. (2002). Balanced scorecard report: Insight, experience and ideas for strategy focused organisations. *Harvard Business School Publishing*, *4*(1), 1–17.

Neely, A. (1998). *Measuring business performance—why what and how*. London: Economist Books.

Neely, A. (1999). The performance measurement revolution: Why now and what next? *International Journal of Operations & Production Management*, *19*(2), 205.

Neely, A. D., Mills, J. F., Bourne, M. C. S., Kennerley, M., Platts, K. W., Richards, H., & Gregory, M. J. (2000). Performance measurement system design: Developing and testing a process-based approach. *International Journal of Operations & Production Management*, *20*(10), 1119–1145.

Senge, P. N. (1992). *The fifth discipline: The art and practice of the learning organization*. London: Century Business Press.

Takikonda, L., & Takikonda, R. (1998). We need dynamic performance measures. *Management Accounting*, *80*(3), 49–51.

Xirogiannis, G., Chytas, P., Glykas, M., & Valiris, G. (2008). Intelligent impact assessment of HRM to the shareholder value. *Expert Systems with Applications*, *35*(4), 2017–2031.

Zhang, W. R., & Chen, S. S. (1988). A logical architecture for cognitive maps. In *Proceedings of the second IEEE international conference on neural networks* San Diego, CA.

Zhang, W., Chen, S., & Bezdek, J. C. (1989). Pool 2: A generic system for cognitive map development and decision analysis. *IEEE Transactions on Systems, Man and Cybernetics*, *19*, 31–39.

Zadeh, L. A. (1997). The roles of fuzzy logic and soft computing in the conception design and deployment of intelligent systems Software agents and soft computing: Towards enhancing machine intelligence concepts and applications. *Lecture Notes in Computer Science*, *1198*, 83–190.

Michael Glykas is Assistant Professor at the department of Financial and Managemen Engineering of the University of the Aegean. His research interests include: business process management, human resource management, performance measurement and fuzzy cognitive mapping.

Panagiotis Chytas is a researcher at the deparment of Business Administration at the University of the Aegean in Greece. His research interests include: performance measurement, information technology, fuzzy cognitive mapping.

George Valiris is an Associate Professor at the department of Business Administration at the University of the Aegean in Greece. His research interests include: information technology, human resource management, business process management.