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Review

New developments in ICM: Image configuration method

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The purpose of this paper is to present the latest format of the Image Configuration Method, created to ensure through proper management, sustainability of organizational reputation as well of its brands and products image. ICM is a method to constantly monitor organization, brand and product image, which reflects on management and communication planning for each year. The method detects problems and opportunities for an organization's image, helping to sustain and develop a good reputation. It has been theoretically developed and empirically tested since 1998, both in academic research and in management consulting.

Key words: Image configuration, image management, image research, image configuration method (ICM).

INTRODUCTION

One of the most important variables defining the consumers' behavior is the image they build about the organization, their brands and products. Business' management abilities include understanding how these images can be accessed and formed in the publics' minds. The multiple definitions of image without accordance among them, have contributed to an unconsolidated method for image measurement in Marketing and Image Theory. Therefore, the main assumption underlying its development, according to De Toni (2005), states that images are representations, impressions, convictions and meaning networks related to an object (product, brand or organization), stored in memory in a holistic way.

A number of tools, routines and methods have been employed to examine the contents and the image organization of a brand, corporation and store. However, there is not any standardized technique already developed (Stern et al., 2001). This study proposes an Image Configuration Method (ICM) as the best way to capture consumers' images regarding a certain study object. So, the Image Configuration Method (ICM) was designed to ensure through proper management, the sustainability of the best possible reputation an organization can achieve, among all its publics.

ICM offers a permanent image monitoring for the organization, its brands and products, with a direct influence on communication planning for each fiscal year.

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The method aims to (i) identify the organization image created among each group of stakeholders; (ii) detect emerging problems in the institutional image for each public, so that they can be solved before representing reputation problems and (iii) detect image improvement opportunities that will enable the sustaining of the firm's good reputation, as well as its evolution over time.

This method was developed through the work of many scholars (Sampaio, 1998; Caieron Júnior, 1999; Chala, 2000; De Toni, 2005) and has been theoretically improved and empirically tested since 1998, in academic research. Between 2003 and 2005, ICM development went through its most structured validity and reliability tests. The testing procedures, as well as a summary of the results, will be presented in this paper. For testing purposes, Cell Phones were chosen as image measurement objects. The research population comprised of undergraduate business students at three universities in the South of Brazil. A nonprobability convenience sampling technique was used.

The purpose of this paper is to present the Method's latest format after the constant evolutionary process it has gone through. Therefore, this research presents after a brief introduction, the Image Configuration Process in which the main stages of the ICM are described for both image identification and strategic image management; lastly the final remarks are presented.

THE IMAGE CONFIGURATION PROCESS

The ICM, presents the following steps: (a) defines the wanted image for the Organization (DNA definition), its brands and products; (b) identifies the target publics (segmentation and segment profile) and its stratification; (c) content configuration of the organizational image: (i) selects the target public and a typical sample for an exploratory phase of the research; (ii) identifies the image's salient attributes, for the target public, as well as to create a distinction between the attributes closer to, and further from, the Inducing Term and (iii) classifies the identified attributes into categories according to the level of perception they refer to (the sensorial, emotional, rational, affective, symbolic, visionary and axiomatic levels); (d) grouping configuration of the organizational image: (i) selects a representative sample for the quantitative phase of the research; (ii) measures the importance and the satisfaction perceived through the image's attributes and (iii) groups the attributes in importance and satisfaction's factors;(e) displays the results in the Image Configuration Graph (ICGraph) and (f) provides suggestions of strategic actions for image management, according to the comparison between the results of data treatment and the DNA declaration, through the suggestions of strategic actions table (SSATable).

DNA Definition

To define the desired image in a clear simple fashion, so that it can be broadly shared both with the general public and with any other particular stakeholder group, ICM proposes a workshop, in which participation of the Board of Directors is essential. Defining the organization's DNA basically means thinking about the nature of its mission, values and vision. These fundamental definitions are the basis for the company's desired core and secondary attributes, which will also be declared in its brands and products. Because these definitions are not always fully aligned to help in defining DNA, an activity, called Archetype Definition, was designed to help achieve this. This workshop offers company workers the opportunity to interact in a light, entertaining, creative and productive way, taking them away from their usual work routines. The activity can remain restricted to the Board, but it can also be fully shared with the whole organization; this will create a general consciousness about and adherence to the declared DNA, helping the future efforts in internal communication.

Archetypes are examples of some of the innumerous primordial images that exist in collective unconscious. They are symbolic images that personify behavioral patterns and value scales. Symbols are powerful images and exert great influence over consciousness. When an organization's strategic staff get together to conceive the firm from an archetypical point of view, its essence emerges naturally and effortlessly, helping to generate the most significant, adequate description on which to build the symbol, the organization wishes to present to the world: its image. This approach naturally leads to a syncretic description of its primordial activity (mission, purpose) and its basic action pattern (principles, values), looking for a construction in the long run (future vision). The creation of an archetype, therefore, generates a forceful expressive symbol, easy to communicate and strongly retained. If expressed through a created personage, then the essential set of attributes designed for the organization's image becomes an easily identified anchor for its stakeholders.

PUBLICS' IDENTIFICATION

The identification of the several organization publics is the first step, because each public presents common characteristics, in relation to the contact they establish with the organization forming, therefore, images that will probably present different trends. Gathering the public's into one research effort could result in a scattered model without focus, which would provide the Communication Manager with little help in his future decision-making process. Otherwise, to treat each public individually would result in a simpler and more precise image.

Table 1. Structured interview for attribute survey

Image Dimensions	Basic Script Questions
Top of mind attributes	1. When I say (Inducing Term), what is the first thing that comes to your mind?
	2. What other ideas come to your mind about (Inducing Term)?
Affective	3. Which feelings come to your mind about (Inducing Term)?
Emotional	4. What do you like about (Inducing Term)?
	5. What do you dislike about (Inducing Term)?
Rational	6. What use does (Inducing Term) have for you?
Sensorial	7. Which physical sensations do (Inducing Term) remind you of (images, sounds, smells, flavors, vibration, temperature, weight)?
Symbolic	8. What does (Inducing Term) represent to you?
Visionary	9. What do you expect of (Inducing Term) in the future?
Axiomatic	10. Which principles or life values does (Inducing Term) help you practice?
Points of Comparison	11. How do you compare (Inducing Term) to (Similar Organization, Brand or Product)?
Projection	12. If (Inducing Term) were an animal, what would it be?
	13. What is this animal like?

Source: Developed by the authors.

Content configuration of the organizational image

During the first survey of an organization's, product's or brand's image attributes, ICM will not determine those attributes *a priori*, but rather leave respondents free to spontaneously verbalize them. Due to the holistic nature of image, measurement models having only previously defined scales (such as hierarchies, attribute listings and rankings) must be complemented by other approaches, for these techniques primarily capture predetermined dimensions, rather than global representations (Dichter, 1985; Zaltman and Zaltman, 2008). In order to reveal the salient image attributes for the object under investigation, ICM proposes a structured interview approach using a Basic Script with questions designed to offer the respondent stimuli to reveal the attributes, at all the levels of reality mentioned so far. Respondents are asked to answer questions in a free, spontaneous fashion without tensions or obligations, criticism or judgment. They are instructed to reveal the first idea that comes to mind, using free idea association (Guimelli, 1994).

The advantage of this technique is that it allows identifying the latent elements in people's minds surrounding the brand's or organization's image without much rational control (Poiesz, 1989; Zimer and Golden, 1988). Based on this, ICM includes two initial questions in the structured interview to permit the respondent this free association of meanings. The other questions offer semi conducted stimuli, leading the respondent to evoke the image of the object under study from other points of view (dimensions of reality and perception). This structured interview can be applied orally or in writing. During instrument testing (De Toni, 2005; De Toni et al., 2011), both formats turned out to be equally adequate. It was noted that all the attributes identified through personal interviews are also present in the written form data collection, the latter having generated in all tests, a greater number of attributes.

Questions 1 and 2 in the interview (Table 1) help indiscriminately identify the attributes in the subject's mind that are more closely linked to the mention of the organization, product or brand name. Those two questions aim to understand generically which type of mental representation the subject holds about the object (Dickson and Albaum, 1977). This way, it is easier to access the often non-rational top of mind contents permeating that image, those which are mostly respon-sible for the purchase decision. The other questions seek to add further complexity to the approach by repeating the same basic questioning from other standpoints (from the various image dimensions), thus forming a scale designed to offer respondents a larger number of opportunities to reveal the attributes comprising their image of the object in the study. The questions produce stimuli to make respondents position themselves from a sensorial, emotional, rational, affective, symbolic, visionary and axiomatic point of view. The logic behind the structured interview development has helped to achieve a form of questioning about those attributes which stands halfway between being simplistic and an extremely elaborated one, whose complex application could hinder its broad utilization in organizations.

Image attributes identification and their category split

The analysis of the collected data is done in three stages. The first stage comprises a content analysis of the interview transcripts, in order to list the ideas verbalized by the participants in the study, thus generating the image attributes. The second step involves classifying the identified attributes into categories according to the level of perception they refer to. In other words, the sensorial, emotional, rational, affective, symbolic, visionary and axiomatic attributes are taken as pre-defined categories of the analysis. Since this classification strongly depends on subjective interpretation, ICM's recommendation to minimize the biases caused by interpretation subjectivity is to have at least three judges identifying the attributes and their categorization (Malhotra, 2006). Analyzing the attribute allocation into categories through ICM, it is easy to perceive which type of predominant relationship the participants involved in the study have, in general with the organization, brand or product (whether sensorial, emotional, rational, affective, symbolic, visionary or axiomatic relationship). This can, quite securely direct the organization's future communication plans, emphasizing arguments at the level of the predominant dimension. This procedure considers image as a multidimensional holistic event. An image is a mental model that represents an object and enables the mind to deal with this object through thinking. This image constitutes an indivisible whole, joining elements (attributes) of different natures (categories) and it can be understood by appraising its diverse forming components in their intimate interaction and mutual influence (Zielke, 2011).

For ICM, an organization or brand image is made up of seven main dimensions. The first dimen-sion (Sensorial Dimension) is the physical level of perception, which generates information directly linked to the material world and to what is captured by the sensorial organs, example, the sensorial attributes (Stern et al., 2001). The second dimension (Emotional Dimension) is formed by the emotional level of perception. The observer makes a judgment about the perceived sensorial data, an evaluation of their interest, usefulness and goodness that provokes moods, interest or affection. These emotional attributes will constitute an important part of the brand or organization image (Martinez and Chernatony, 2004; Ledoux, 2001; Aaker et al., 2011). The third dimension (Rational Dimension) of consciousness towards a perceived object is the mental level of perception, in which evaluations of a pragmatic, functional and logic kind nature are made. This generates the image's rational attributes (Deely, 1990). The information captured in the first three dimensions of perception grant to the individual the affective level of perception, featuring the fourth dimension (Affective Dimension) which, differently from the reactive, emotional level, contains more elaborated feelings. Such feelings assess the value of the object for the individual's socialization and affective interaction with the environment, leading to the recognition or denial of its usefulness, to respect show gratitude for its existence and to a valorization of its characteristics. These are the affective attributes that act upon the decision making process in favor of a brand or organization (Park et al., 1986).

The fifth dimension is related to symbolic level of perception (Symbolic Dimension) which allows the already named and categorized phenomenon to be included into the mental sphere, generating closer connections to the signs already present in the individual's repertory. Thus individuals, getting in touch with an object, also take into consideration its symbolic attributes, for example, whatever it may represent to them (Levy, 1981; Dichter, 1985; Rucker and Galinsky, 2008) and what it may connote and denote about the individuals in their social relations. According to Cayrol and Saint Paul (2010), distortion is the process that let us introduce change into our sensorial experience and reinvent what is perceived, generating the sixth dimension (Visionary Dimension), to take into account the visionary level of perception, which re-describes the world according to what we wish, fear or decide. It is not what the individual sees, tests and possesses but what he idealizes about the organization or brand, often projected as future expectations. The visionary attributes constitute an important image dimension for organizations seeking to profit from their stakeholders' tendencies, in order to favorably improve their image and reputation. Finally there is the seventh dimension (Axiomatic Dimension) related to axiomatic level of perception, involving the main values an object may represent for people, who will search for and adopt it when they realize that it helps them live in this world by their personal life principles (Roehrich et al., 1989; Beatty et al., 1996). This level is connected to the very meaning of a person's life and to his perception of purpose (mission) and principles.

When an organization or brand image is conceived as a holistic event, made up of many dimensions interacting to constitute its reality, assessing it through research also requires thinking in a methodologically holistic way. Seeking to grant content validity to the procedure, references from other authors, addressing the same issue with similar purposes, were searched (Zimer and Golden, 1988; Abric, 1996; Sá, 1998; Vergès and Tyszka, 1994; Sampaio, 1998; Caieron Júnior, 1999; Chala, 2000; De Toni 2005; Schuler et al., 2009). The results they found inspired designing the format used for questioning the sample in this step of the ICM. Other studies underlying the interview development, apart from the already mentioned, acknowledged the presence of several attribute categories. Some of them defend the holist approach to mental image (Zaltman, 1996; Zaltman and Zaltman, 2008; Dickson and Albaum, 1977); some an informal tone for the interview (Poiesz, 1989) and others the use of projective methods. Some studies deal with the importance that the meaning of the image object holds for individuals (Levy, 1981), while others consider its usefulness (Cardozo, 1974; Stern et al., 2001).

Table 2. Example of value ascription to attributes.

S\N	Variables	Respondents (n=10)																					
1	ID	1		2		3		4		5		6		7		8		9		10			
2	Gender	F		M		M		F		F		M		F		M		M		F			
3	Age	25		32		48		21		23		33		34		40		38		26			
4	Segment	Sales		RH		Mkt		PR		PR		Mkt		RH		Sales		RH		Mkt			
	Attributes	**VO**	**VF**	**VO**	**VF**	**VO**	**VF**	**VO**	**VF**	**VO**	**VF**	**VO**	**VF**	**VO**	**VF**	**VO**	**VF**	**VO**	**VF**	**VO**	**VF**	**VT**	**Dimensions**
5	Ethics		1	5	1		1	1	1	4	1	2	1	5	1	3	1	5	1	2	1	37	Axiomatic
6	Social responsibility			2	1			2	1	3	1		1	4	1			4	1			21	Affective
7	Recognized	4	1	1	1	5	1	5	1	5	1	4	1	1	1	2	1	3	1	1	1	41	Symbolic
8	Profitability	5	1			2	1		1		1	5	1		1	5	1			5	1	20	Physical
9	Bravery	3	1		1	4	1	4	1	1	1		1			1	1			4	1	25	Emotional
10	Promising	2	1	3	1	3		3	1	2	1	3	1	2	1	4	1	2	1	3	1	37	Visionary
11	Organized	1	1	4	1	1			1			1	1	3	1		1	1	1		1	20	Rational

Source: Developed by the authors.

Identifying the attributes centrality

The third stage of content configuration using ICM refers to the frequency and order of appearance of the image attributes generated by content analysis of the interviews, for the organization under study. This procedure was initially proposed by Abric (1996) and Vergès (1992) with the purpose of creating a distinction between the attributes closer to, and further from, the inducing term. In ICM, only the first five attributes cited by the respondent receive order values (the first one cited = 5; the second cited = 4; the third = 3; the fourth = 2; and the fifth = 1). All the attributes cited during the interview receive a frequency value (= 1 per respondent). The attributes generated by the content analysis are listed on a table (Table 2, below) indicating their order values (OV), frequency values (FV) and their total values (TV = OV + FV)

Assigning an appearance order value differentiates the most salient among the several cited attributes. This procedure seems reasonable because, when an attribute is cited in the first place, this indicates a strong connection to the object’s mental image in that particular respondent’s view. This theoretical assumption has also been adopted by researchers in social representations and central nucleus theory (Abric, 1996; Minayo, 1997; Moscovici, 1997; Vergès, 1992; Vergès and Tyska, 1994; Sá, 1998), when they used a similar procedure to distinguish the structural elements of the central nucleus of social representations, in the methodological design proposed for that goal.

The total values, achieved by combining attribute order and citation frequencies, are utilized as parameters to locate them in different areas of proximity to the inducing term, (that is, the organization’s name). The listing of total values is analyzed using the quartile division technique, which yields four intervals. The interval generated by the highest values, holds the attributes considered pertinent to the core image. The quartile corresponding to the interval with the next highest values is considered as the first image periphery. The quartile representing the interval with third higher values is called second periphery. The quartile with the lowest values is simply called image margin. The quartile division derives from studying the results of other procedures (Abric, 1996; Minayo, 1997; Vergès and Tyszka, 1994) and from all the research prior to the development of this instrument (Sampaio, 1998; Caieron Júnior, 1999; Chala, 2000). Both in quan-titative as in qualitative studies, the most relevant attributes for image formation made up a per-centile close to twenty five percent of the total of attributes revealed. After verifying this, the quartile division was adopted to meet the Method’s purposes. Adopting this criterion as a process has generated constant indications of efficiency (De Toni, 2005).

The image attribute analysis by ICM so far described, constitute the image content configuration stage, whose methodology chosen to verify reliability uses such methods as test-retest, alternative-forms and internal consistency, as well as convergent and pragmatic validity (Malhotra, 2006). To test-retest reliability, data collection was made at two different times, with a seventeen-day interval and with the same group of respondents (94 undergraduate students in São Paulo, Brazil). As a result, round one interviews revealed 31 attributes, whereas round two interviews revealed 29, with a 2-attribute difference in relation to the first. The procedure's alternative-forms reliability and convergent validity were assessed by submitting the same data set to ICM and to an alternative procedure, normally employed by researchers for the same purpose. The EVOC, software used in social psychology is a tool, broadly validated and accepted in academia, to define the core set of an image's attributes (its social representations). A comparative analysis of the results in both tests showed that the five attributes identified as core image components (based on Vergès and Tyszka' (1994) criteria are 100% present in the core image configured through ICM (De Toni, 2005). The same precision was not found in the image peripheral system, indicating the need for further studies to search for reasons for this divergence and to refine the approach for more precision.

Internal consistency reliability was assessed applying the split-half approach to the sample. The test results show that, among the eight attributes identified as cell phones' core image components by the total sample, only one is not present in half 1 and only one attribute is absent from half 2, indicating a 87.5% coincidence. Applying the split-half approach to the attribute breakdown by categories, a .85 Pearson correlation coefficient was obtained, being that this correlation significant at the level of .01 (De Toni, 2005). Seeking further evidence of validity, the attributes and their relative positioning generated by the ICM procedure were compared, using content analysis, to the attributes and metaphor levels (deep, theme and superficial) identified in a previous study carried out by Kraft and Nique (2002) using ZMET (zaltman metaphor elicitation technique), also to configure cell phone image among the same universe of university students. From the 18 categories found by Kraft and Nique (2002) using ZMET, only one attribute was not identified by the ICM procedure. Another important comparison between ZMET's and ICM's results are the set of attributes grouped at the level of deep metaphors (ZMET) and the attributes comprising the core image (ICM), which present an important level of coincidence. Those two figures can be considered as theoretically equivalent. The results provide evidence of possible convergent validity for this set of ICM procedures and encourage recommending future research to generate further evidence (De Toni, 2005).

In order to verify pragmatic validity in the procedure to distinguish between core and peripheral image attributes, two similar samples were drawn from the same universe. A reverse test was run, in which the respondents in the first sample were administered the set of cell phones attributes located through ICM in the core image, to verify if respondents could identify which product those attributes referred to. The second sample was administered a set of cell phones peripheral attributes, as defined by ICM. So, in the first stage of the research, interviewees were asked to answer what first came to their mind when the product name (Cell Phone) was mentioned. In the reverse test, the opposite was done; in other words, the aim was to identify which product came to mind when that set of attributes was presented to the respondents.

Presenting cell phones' core image attributes to the first sample provoked recognition by 90.9% of the 44 respondents, while only 4 of them (9.1%) identified those attributes as a computer. But presenting cell phones peripheral image attributes resulted in a significant drop in product recognition: only 47.7% of that sample declared that the attributes belonged to a cell phone. Fifty percent (50%) of the sample identified a computer in the set of attributes and even one respondent (2.3% of the sample) thought of a robot.

These results suggest discriminant validity for the instrument, since the measurement of core image attributes differs significantly, due to product recognition, from the measurement of image margin attributes. Such difference is supposed to be generated by using the instrument. From the results obtained with the sequence of ICM procedures for image content configuration starts the grouping configuration stage, which will be presented in the next section.

GROUPINGS CONFIGURATION OF THE ORGANIZATIONAL IMAGE

ICM's next steps in analyzing an organization, brand or product image consist of: (i) measuring perceived importance for image attributes; (ii) measuring perceived satisfaction with those attributes and (iii) grouping attributes into factors (importance and satisfaction factors). Applying ICM in the development and testing phases showed that there is no significant relationship between an attribute's total value, as revealed in the content configuration phase and the importance given to it. We found attributes with high mean importance scores in the image margin, as well as attributes with low mean importance scores in the core image. Identifying the degree of importance for each attribute, together with their level of perceived satisfaction among participants in the study, is important information for image management, helping to detect problem areas and image opportunities, as well as to define the focus for future management of the organizational image.

Importance factors help in identifying the networks of

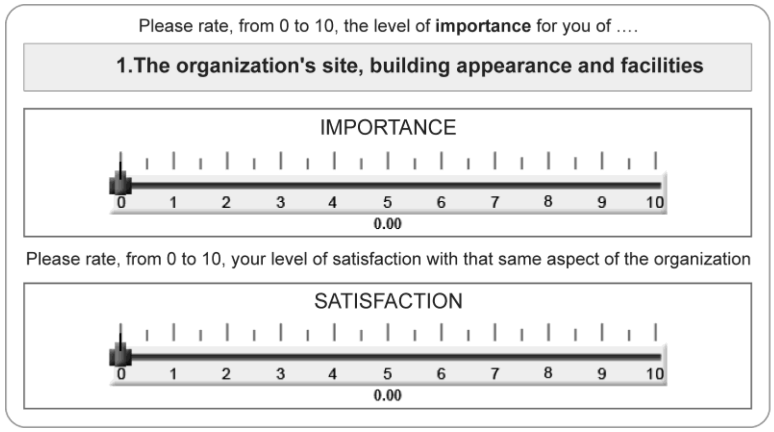

Figure 1 Scales used in measuring image attributes' importance and satisfaction.
Source: Developed by the authors.

meaning created inside the mental model of the participants involved in the study. Each generated factor reflects the closest interconnection of a data set in the mental model, according to the idealized image the respondents have formed regarding the organization or brand. Satisfaction factors help in understanding the networks of attributes that interrelate to create respondents' satisfaction with the organization or brand. Generating satisfaction factors is useful for future image management because, when two closely related attributes (for example.: price and quality) are found, improving satisfaction with one of them will probably entail improving satisfaction with the other, as they tend to vary jointly in the minds of consumers in that segment.

The groupings configuration stage is performed with another sample, equally representative of the same universe (same public) and much larger than the sample used in the content configuration stage (this one can be included in the new sample). Using random samples selected via usual sampling methods is recommended.

Measuring the importance and satisfaction's levels of the image attributes

This segment is intended to measure the importance and satisfaction degree concerning the product attributes raised in the content configuration. Such procedure may be optional according to the objectives of each organization. This is important to identify how important and satisfied one is in respect with the most outstanding attributes in the mind of the target public.

Developing the importance and satisfaction questionnaires is done by using the list of attributes revealed during the first stage survey, accompanied by an importance and satisfaction scale that respondents are asked to check. In the latest ICM format developed, attribute importance and satisfaction are measured using ratio, metric, numbered scales (Hair et al., 2005), for digital media, on which respondents score the importance and satisfaction (raging from 0 to 10, according to Figure 1) for the image attributes previously surveyed. According to Figure 1, the use of a scale to measure the importance or satisfaction is generated by a disposition of an attribute list raised upon the content configuration stage, followed by interval scales of Linker sort, on which the respondents attributed a degree of importance or satisfaction for each analyzed attribute.

Grouping the attributes in importance and satisfaction factors

After this step in the measurement process, attribute importance and satisfaction mean scores are added to the information on the linkage between attributes and the image object. Importance and satisfaction ratings are used to generate the importance and satisfaction factors and to identify the nature of the links among the image elements that are being configured.

The procedures used in the groupings configuration stage were tested for validity and reliability. Evidence of alternative-forms reliability, convergent and pragmatic validity was searched. For the test with cell phones, a mentioned above, a questionnaire was developed using the results of the attribute list revealed in the content configuration phase, and pretested with a sample of 35 students chosen through a judgmental sampling technique. Another sample of 322 students was used to collect the data used in the other testing procedures (De

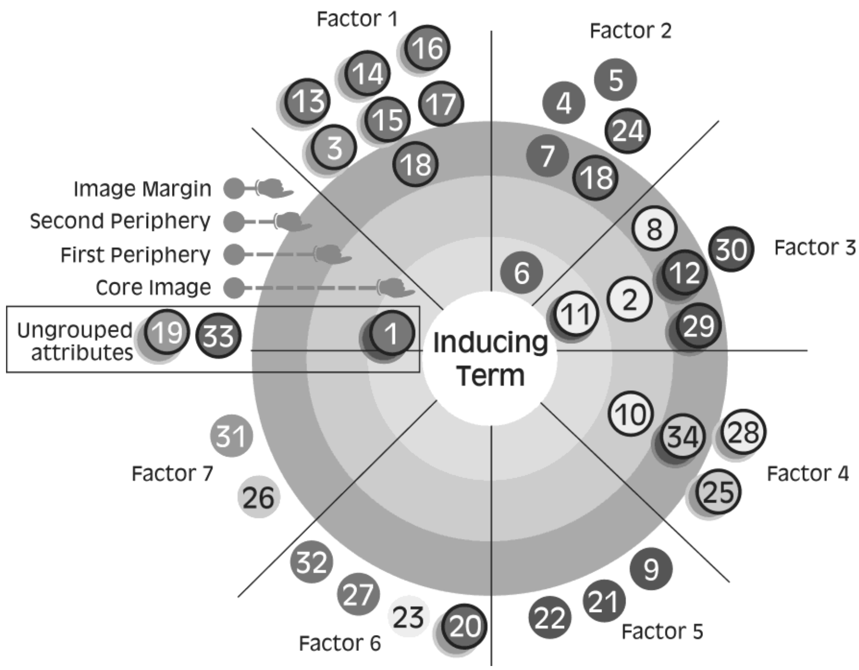

Figure 2. ICM's Image Configuration Graph.
Source: Developed by the authors.

Toni, 2005).

Convergent validity and alternative-forms reliabilities were tested for the method, through a comparison of its results especially those treatments created by Régis Gras (Gras et al., 2006) for the same purpose (the CHIC software). The same set of data was analyzed, in order to check how precisely factor analysis outlined the groupings as compared to CHIC (De Toni, 2005). The results obtained show that, among the 25 image attributes of cell phones, 21 (84%) of them were grouped the same way both by factor analysis and by the similarity analysis done by CHIC. The chosen way to approach the procedure's pragmatic validity was a reverse test, or an interinduction test of the aggregated attributes. This procedure uses the attribute with the highest factor loading in each grouping, together with the product name, as a stimulus to evaluate the power, this pair has to evoke recall of the remaining factor components. In average, all the testing done for this procedure yielded an 85% coincidence of the attributes belonging to the factors with the ones cited by respondents, when the attribute with the highest factor loading was used as inducing term.

PRESENTATION PROCEDURES

Based on the results in the content configuration and groupings configuration stages, a report is produced, consisting mainly of an image configuration graph and a suggestion of strategic actions table.

The image configuration graph (ICGraph)

Based on the results of data treatment, a graph can be drawn to display those results (ICGraph), as in Figure 2, below. It gives an example of employing this method to configure an organization's internal image. Laying out the research findings graphically help to visualize the studied image configuration synthetically. The graphic presents several basic information and constitutes a practical tool to direct the strategic actions of an organization in relation to its products and services.

Visually displaying such important information on a graph helps decision making in areas like institutional, marketing and business communication. The first important piece of information is how close image-forming attributes are to the inducing term. The example of ICGraph in Figure 2 shows that the organization's core image is made up by the attributes "employees' personal and professional value recognition" (11); "personal well-being at work" (01) and "current salaries" (06). These attributes conceptually define the organization for this public, for they were the most promptly and frequently mentioned by the sample of workers involved in the study. All the remaining information in the mental model lies in different areas of the image periphery. We could build a description of this firm, from people who work there, such as “an organization that valorizes its staff, taking care of their well-being at work and a remuneration that could be better”. The second most relevant piece of information is the possibility to visualize the attributes considered extremely important (outlined in black) and extremely satisfactory (with a grey shade) by that public. At the same time, the graph depicts each attribute in colors representing its dimension (sensorial = red; emotional = orange; rational = yellow; affective = green; symbolic = indigo; visionary = dark blue; axiomatic = purple), forming a complete picture of the necessary information to understand the image at that particular time. Of the attributes forming the core image in the example above, it can be said that “employees’ personal and professional value recognition” (11, affective) is both extremely important and extremely satisfactory. This represents a very positive point for the organization to use as a favorable argument with this public whenever necessary. “Personal well-being at work” (01, emotional) is also an extremely important and satisfactory attribute, indicating a very favorable position for the organization in the view of its employees. “Current salaries” (06, sensorial) were not considered satisfactory; this is not rare, for it is quite difficult to have someone declaring a total satisfaction with one’s pay. It is quite interesting, though, to notice that salaries were not considered extremely important, revealing a reasonable degree of satisfaction by employees, who feel they work for this organization for more important reasons than money alone.

We can infer that the set of attributes considered by the public involved in the study as an important elements of the organization’s concept are those corresponding to the idealized organizational image. It is this set of attributes the public desires for the firm. So, Factor 1, in Figure 2, unites some of the attributes referring to the “quality of services rendered by the organization” and is considered important as a whole (including all its attributes) by the internal public. However, most of these attributes are in the image margin, for example, they are not immediately recalled by this public as part of the organization’s mental model. This is an important clue for communication managers, since they can learn from these results that the organizational image could become more favorable for this public, if the quality factor were brought closer to the core image.

The suggestions of strategic actions table (SSATable)

Observing the image configuration graph (Figure 2), some conclusions can be drawn about the current state of an organization’s, brand’s or product’s image in the view of a particular public. ICM offers a fairly standardized way of displaying those conclusions to help concerned managers and top management discuss them. The purpose of the image configuration graph is to become a strategic tool for image management. Thus, from the relative position of each attribute on the graph, it is possible to direct communication strategies according to the organizational goals. A report of the proposed strategies, in table form, analyzes the main attributes according to their positions, values and relationships, showing possible directions for a better management of that particular image.

Table 3, presents the basic format suggested to display and discuss the results of ICM’s application. The table is called suggestions of strategic actions for image management. According to the position of each attribute before the proximity in relation to inductor term and its perceived importance, distinct managerial actions can be out into action according to the organization’s objectives. Therefore, the closer an attribute is to the inductor term and the larger its relative importance for the respondents, the attribute is likely to be stronger upon the purchase decision. For Abric (1996), the attributes located close to the inductor term depends on the frequency, regency and vivacity with which a certain public perceives the attribute attached to the studied product image. Therefore, upon proposing modifications in the proximity of the attributes that belong to the central image, a larger investment of time and resources is needed, since they are vividly present in the target public’s mind.

So, employing ICM generates a considerable volume of information on the organization, brand or product image. This information, spontaneously evoked by the participants involved in the study without any attribute definition *a priori*, is strategic for organizational communication management as it shows the ways for decision making in strategic planning for the next fiscal year. In this sense, the many applications of ICM are able to reveal its power as a strategic management tool, one which has been gradually adopted by organizations as the main guideline for their yearly strategic planning.

FINAL CONSIDERATIONS

Images constitute one of the most important intellectual for human beings, which is able to influence and direct people behavior. Therefore, the comprehension of images that several publics form about a product constitutes an important competitive edge in the direction of placement strategies of an organization or production in the market, as well as for the communication compound to better support its performance in the market.

Zaltman (1996) states that due to customers’ complex behavior, this phenomenon needs to be approached in a multidisciplinary way, in a holistic way, in which body, mind, emotions and spirit can be equally and interrelatedly considered. A better understanding about people implies understanding them thoroughly, not only one

Table3. Suggestions of strategic actions for image management (SSATable)

Position	Attribute Type		Strategic Actions for Image Management
Core Image	Positive	More Important	When an attribute positive for the image and important for employees is in the Core Image, this position should be kept, first by making sure that the attribute is always present and constantly improved. Secondly, the attribute should be stressed in communications to become linked to the idea under investigation. This attribute is an excellent argument and may represent a persuasive differential, in some cases.
		Less Important	When an attribute that is positive for the image is in the Core Image but is not perceived as very important by employees, it may require less maintenance, but not to the point of complete neglect. A good internal communication job may stress the attribute's importance and throw it into the spotlight.
	Negative	More Important	Finding in the Core Image an unfavorable image attribute, that is considered as very important by employees, demands disconnecting this attribute from the idea under investigation. This can be done through intense communication efforts, including reinforcement of more positive attributes, over which the organization has control.
		Less Important	These attributes should be separated from the Core Image, while other desirable concepts are reinforced. This is less serious than cases where the attribute is considered important.
Peripheral Image	Positive	More Important	Intense use of communication, linking the attribute to the communication theme to frequently reinforce it and to bring it closer to the Core Image. Depending on the case, it may be convenient to replace a negate attribute in the central position.
		Less Important	Whenever possible, use communications to reinforce these attributes, to bring them closer to the Core Image and to increase employees' perception of their importance. They can be used as substitutes for negative attributes in the Peripheral Image, in efforts to disconnect the negative ones coupled with actions to reinforce the presence of these positive attributes in employees' minds.
	Negative	More Important	Work, whenever possible, to disconnect these attributes from the image, both in its identity as in its communication. Reduce the perception of their importance, stressing other aspects considered more positive.
		Less Important	The less reference is made to these attributes, the more likely they will be forgotten.

Source: Developed by the authors.

single aspect. Thus, reality levels through which ICM approaches images match the conscience level to which people have been having access along their vital development. From different studies carried out in both academic and practical contexts (De Toni, 2005) it has been identified that ICM is a valid and reliable tool to measure and better understand how images configurate in the mind of the target public being studied.

Among the managerial implications of ICM, one must highlight that research efforts must be directed to identifying how consumers perceives products, brands, prices, organizations and how these influence their choices (Boom, 2011). The formation of any strategy of communication and image strengthening may begin with an analysis of images consumers have of the studied object. Identifying and measuring the dimensions that compose a product image, brand or organization helps define strategies, mainly when focused on satisfaction and retention of customers within a perspective of customers' lifetime value in order to reach profitability for the organization (Kamakura et al., 2002). Once identified, the image configuration of the investigated object before a certain public, the communication manager is supposed to influence the organization's guidelines so that each contact of the target public with the organization can be an agent to form the intended image.

After twelve years of development, application and constant evolution, ICM represents a valid and trust-worthy method for organizational reputation management. Each and every one of its procedures have been repeatedly tested for validity and reliability (Sampaio, 1998; Caieron Júnior, 1999; Chala, 2000; De Toni, 2005) and its application is constantly reviewed for greater practicality. New applications, however, may indicate new paths for development, as well as new evidence of its effectiveness.

Finally, it is worth remarking that this new evolutionary step of ICM, image configuration method of images, brands, products and services, in its procedure of content configuration represents a progress in the efficacy with which ICM reveals an image of objects of marketing management. This extension of sight to several dimensions that compose a market image reduces risk margin for loss of opportunities to explore argumentation, on behalf of organizations, brands and products, taking into account outstanding, important and determinant aspects for consumers' markets in their purchase decision. As these decisions are recent, forthcoming research suggestions regard active experimentation in this form of image treatment, thus allowing the discovery of refinements more and more meaningful upon the consideration of multidimensional market image.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Full Length Research Paper

Causality analysis of the technology strategy maps using the fuzzy cognitive strategy map

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The main purpose of this study is to find out the causality relationships between the strategic management of technology (SMOT) objects in the selected Iranian high technology companies, based on the balanced scorecard (BSC) and fuzzy logic approaches. Evaluations of critical technological indicators in the selected high technology-based companies illustrated they have used different cognitive procedures in their strategic management of technology studies, which have previously been discussed throughout the SMOT literature. Technology strategy maps try to make convergences between the objects of SMOT using benefits of the technology balanced scorecard (TBSC) in the high technology environment. Technology strategy maps empower high technology companies in both technology and business areas, based on the four perspectives of proposed TBSC. The first step in our evaluations is based on-field studies questionnaires responded to by 150 personnel from different industries. The next step is based on the empirical collected data from 24 high technology companies; causal and effect relationship analysis between each of these objects was calculated and mapped using the fuzzy cognitive map (FCM). Obtained fuzzy cognitive strategy map (FCSM) simply explains the causality relationships between the objects of the SMOT, which were not well understood in the traditional technology strategy maps.

Key words: Strategy maps, high technology, SMOT, BSC, FCM, FCSM.

INTRODUCTION

In the last decade, the emergence and rapid growth of high technology based companies have accelerated the need for innovative and validated strategic models for business and also provided a capable context for research on these subjects. Industrial interests are in how to effectively manage science, innovation and technology indices, which are growing rapidly in the organizational context. Due to the complexity, dynamics and rate of technological innovation prosperities during increase in organizational and progressive sectors change on a global scale. Changing technologies, such as nano-technology, biotechnology, information technology (IT) and social technology require noticeable opportunities to enforce sectors and provide growth; but they also

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present a potential threat to existing activities of firms. Strategic management is the most expanding topic both theoretically and practically, owing to its multi- disciplinary and multifunctional nature. A number of disciplines are relevant to the academic perspective, such as science, engineering, economics, sociology and psychology. In high technology businesses, contributions from both commercial, technological and strategically functions are critical if correct decision making, and successful products and services are to be delivered to the market. This paper based on the literature findings and qualitative and quantity information obtained in the Iranian high technology companies classifies business strategy and technology strategy objects from four main balanced scorecard perspectives. In defining our SMOT framework, we compose suitable technology strategy map (TSM) from strategic management of technology point of view. TSM is based on practical studies on the 24 selected high technology companies from different industries such as chemical fibre, micro-electronics, precision machinery, civilian aircraft, biotechnology, nanotechnology, software and energy development. Using the fuzzy cognitive maps (FCMs) logic, we expand technology strategy map to a dynamic technology strategy map, named FCSM. FCSM not only shows how technology and business strategies integrate in one cognitive map, but also shows causality relationships and degrees of interrelations between objects in both strategic and technology management. Also it shows the best interrelations among SMOT objects by jointed-cycles and paths in the high technology environment.

This framework is developed based on fuzzy systems by obtaining qualitative and quantitative information on enterprise practices. The empirical and theoretical research was conducted in 2012-2013. The research project was conducted for eight months to develop the technology strategy map using 24 large and small to medium-sized high-technology companies; 150 informants were involved.

The proposed framework that helped us to overcome BSC defaults and failures in the evaluations of high technology companies' performances not only considers business objects, but also spots technology objects. Consideration of correct cause and effect relationships among objects in the technology strategy maps gives us a conceptual insight into monitoring and controlling objects to achieve determined goals (missions). This is empowered by merging fuzzy systems and soft computing systems using fuzzy cognitive maps notions. FCSMs easily show cause and effect relationships, which are extremely important for achieving convergences in strategic management of technology actions.

LITERATURE REVIEW

Technology has different definitions: Pugh and Hickson (1976)defined technology as “equipment”, Reeves and Woodward (1970)defined it as “tools” and finally Thompson and Bates(1957) understood it equals with the term of “hardware". Schon (1967) sees technology as each method's tools, product, process, physical equipment or capabilities in production or doing something which is beyond human capability. Technology is all of the knowledge, products, processes, tools, methods, and systems employed for the creation of goods or in providing services (Khalil, 2000). Margaret and Bruton (2011) integrated these various definitions to define “technology” as the knowledge, products, processes, tools, and systems used for the creation of goods or in the provision of services. Although there is a wide variety in the prior definitions of technology, each definition implies that there is a process involved at the heart of technology: that change is an outcome of technology, and that technology involves a systematic approach to deliver the desired (improvements, objectives, and outputs) outcomes (Margaret and Bruton, 2011). The definition of technology also implies a process that involves the elements of strategic management. Technologies not only improve performance management systems (PMS), but also use performance management systems to map the best strategic roads, helping firms to reach their targeted goals and obtaining determined technological objects. Management of technology (MOT) is an interdisciplinary field that integrates science, engineering, and management knowledge and practice (Khalil, 2000). Therefore, the definition of MOT should also reflect this systematic, strategic approach. Management of technology is defined as linking engineering, science, and management disciplines to plan, develop, and implement technological capabilities to shape and accomplish the strategic and operational objectives within an organization. The major shortcoming of this definition is its lack of attention to evaluation and control, which are required for a strategic approach in the management of technology. Evaluation and control involve monitoring technology to ensure that it meets the desired outcomes. It is necessary that after a technology is implemented, the firm monitor changes that may render the technology obsolete, dangerous, replaceable, or competitively weak. A leading example on the need for such evaluation and control is the National Cash Register Company (NCRC). NCRC embarked in the 1960s on their project, because they had no methods and procedures of strategic management of technology (SMOT) in their managerial and control processes (Margaret and Bruton, 2011).

SMOT takes a firm strategic management approach on the subject. Also SMOT offers practicing managers an analysis of how firms should respond to the rapid changes in technologies and innovations that are forcing industries to find new ways to compete. Khalil (2000) categorizes technology according to intense of definitions elements to emerging technology, high technology, low technology, medium technology and appropriate technology. In the high-technology companies, technology may be very complex or progressive. Rogers and Larsen (1984) mentioned the attributes of high-tech firms as follows: an abundance of scientists and engineers within the organization; fast-growing industry; higher R&D expenditure than in any other industry; worldwide market for products. Wheeler and Shelley (1987), for example, investigated forecasts of demand for innovative high-technology products and found them to be uniformly optimistic by 50% or more. They attribute this to a lack of forecaster expertise in consumer behavior, over enthusiasm for high technology, and poor judgment. High technology start-ups, on the other hand, typically aim for future success as the payoff for current activities. These firms need at least an informal and agreed-upon view of their TDS to develop and execute a technology-based business plan. For instance, in devising indicators of high technology development among nations, Roessner et al. (1996) used technology sales as surrogate production measures. This raises some interesting questions of the nature of high technology firms in developing countries and about their experiences; in particular what factors, especially R&D expenditure lead to success. High-tech products are the fastest growing segment of international trade and some 25% of exports from developing countries are in hi-tech products. Others have studied the locational preferences and patterns of different high-technology industries such as biotechnology (Haug and Ness, 1993; Hall et al., 1987) and software (Egan, 1994).

There was different formulation for SMOT named discontinuity in SMOT formulation, entire field of strategic technology management is ambiguous and literature on theoretical frameworks is diverse. Linking business to technology is a managerial challenge in enterprises. Strategic management of technology is assumed to provide a solution to manage complexity caused by technology in dynamic environment (Burgelman et al., 2001; Dodgson et al., 2008). Management of technology is often conducted as part of R&D management or innovation management (Drejer, 1997; Edler et al., 2002; Tidd, 2001). Drejer (1997) has described four schools of management of technology that emphasize R&D management, innovation management, technology planning and strategic management of technology (SMOT). According to Edler et al. (2002), so called 4th generation R&D management sees R&D and technology as strategic instruments for competitiveness and innovations, and stresses theory of explicit technology strategy and integration of technology with business strategy. Current themes in R&D management are open innovation, networked R&D and knowledge management (Chesbrough, 2006; Lichtenthaler, 2008). Innovation management school emphasizes on anticipating technological changes and incubation of innovative products for commercialization. In the technology planning school, the major scope is to manage technology across the company using specific management methods like road mapping and portfolio management (Cooper et al., 1998; Tidd, 2001). SMOT school combines technology and business perspectives through management of technology activities (Phaal et al., 2004; Lichtenthaler, 2008).

Multiple theoretical and practical frameworks for describing elements of technology management have evolved. The entire field is confusing and boundaries of ideas are blurred, and there are no commonly accepted frameworks (Phaal et al., 2004; Brent and Pretorius, 2008; Cetindamar et al., 2009). In Table 1 is presented main types of technology management frameworks. Each of the framework types emphasizes particular aspects of technology management: processes, routines, methodology, need to integrate technology management with core business and strategic processes, or technology management as management of knowledge flows.

BSC is born from this rich history of measurement and serves the same purpose to business as the timepiece served the ancient mariners. The balanced scorecard is a performance management system that enables businesses to drive strategies based on measurement and follow-up (Figure 1). Since the early 1990s, the balanced scorecard has been applied in numerous large organizations resulting in many positive results that have been chronicled in the management literature (Gumbus, 2005; Koning, 2004; Neely, 2005).

Marr and Schiuma (2003) claim that the BSC is “the most influential and dominant concept in the field of performance measurement research” (Marr and Schumia, 2003). Neely (2005) notes its impact on practice, citing research showing that anything between 30 and 60 percent of firms has adopted the BSC in some form. In academic research, Kaplan and Norton’s writings on the BSC have dominated the citations in articles on performance measurement in the leading academic journals for the last decade (Neely, 2005).

Previously, BSC was considered as an organizational performance measurement tool from four key areas. Since then it has grown into a device for controlling the

Table 1. Main types of technology management frameworks.

Technology management framework type	Example reference
Generic process model	Gregory ,1995; Cetindamar et al., 2009
Technology management functions	Kropsu-Vehkaperä et al., 2009
Technology management routines	Levin and Barnard, 2008
Technology strategy approach	Burgelman et al., 2001
Innovation funnel	Wheelwright and Clark ,1992
Knowledge management	Nonaka, 1995
Methods and tools approach	Phaal et al. 2006;Gerdsri et al., 2009
Integration into core business processes	Metz 1996; Phaal et al., 2004
Integrated management concept	Tschirky, 1991

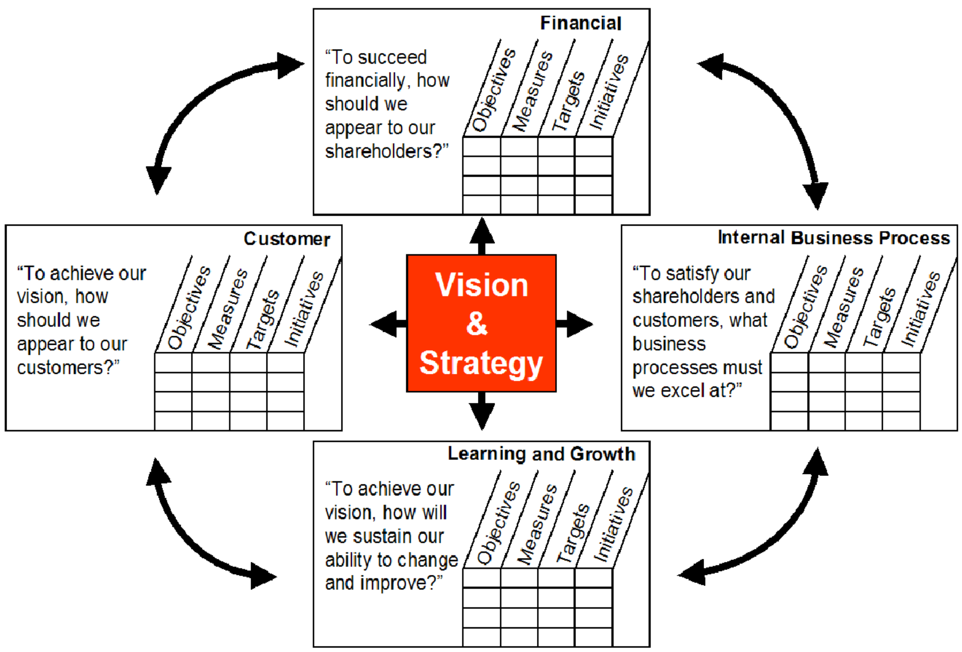

Figure 1. The balanced scorecard and its four aspects.

implementation of strategy (Fink et al., 2005). BSC plays an important role in the strategic performance management studies in high technology companies by linking the performance measures to organizational strategy and goals (Kaplan and Norton, 2000). It has become one of the preferred strategic performance management tools of many prominent public and private sector organizations (Radnor and Lovell, 2003).

The balanced scorecard (BSC) introduced by Kaplan and Norton consists of both financial and non-financial measurements. Kaplan and Norton's BSC classified all technologically developmental indicators into four main perspectives; financial perspective, customer perspective, internal processes and learning and growth perspective (Kaplan and Norton, 1992; Nair, 2004). Kaplan and Norton considered most important principles in their BSC with understanding that a strategy should present the causal model of a company. To do this, the causal relationship between the four perspectives of the BSC is graphically presented in a strategy map which links an organization's BSC to its strategy; cause and effect relationships, performance drivers, and linkage to the financial goals (Kaplan and Norton, 2001). A strategy map is based on the hypotheses comprising causes and effects. Strategy map expresses causal relationships in a sequence the chains of cause-and-effect relationships among the four perspectives of BSC’s objects, which reflect dynamically the change of strategies and describe "how an organization create its fundamental values" (Kaplan and Norton, 2004).

Fortunately, up till now some extensions and expansion of balanced scorecard and strategy maps built have been applied in the high technology companies, commercial companies and other types of companies. For example, Amado et al. (2012) integrated the balanced scorecard and data envelopment analysis (DEA) to improve powers of performance assessment in the multinational companies. Tseng used ANP and DEMATEL methods for making new framework for evaluations of Taiwan university's performances from BSC perspectives and exhibited fuzzy network balanced scorecard (FNBSC) as a new form of BSC (Tseng, 2010). Wu et al. (2011) considered 36 indicators in four perspectives of BSC evaluated in educational centers of Taiwan using DEMATEL (Decision making trial and evaluation laboratory), ANP (Analytical network process), VIKOR methods. Furthermore, Wu (2012) proposed another framework for composing strategy maps for 34 companies within the banking industry using DEMATEL technique for considering correct casual relationships among the Key performance indicators (KPI). Eilat et al. (2008) integrated DEA and balanced scorecard approaches for evaluating the R&D projects in their different stages of life cycle. Wang et al. (2010) integrated hierarchical balanced scorecard with non-additive fuzzy integral for evaluations of two Taiwan high technology firm performance, considering the interactive relationship between BSC’s different perspectives in the performance area. They applied traditional definition of BSC as a tool for measuring the performances of high technology firms from four BSC perspectives.

In this paper, technology balanced scorecard (TBSC) is considered as a framework for SMOT in the selected 24 Iranian high technology companies. TBSC is a strategic framework for management high technology companies which integrate business strategy and technology strategy as a solution for sustainable growth and maintenance for competitive advantages in today’s turbulent environment.

METHODS OF RESEARCH

From strategic management perspective, the role of technology in value creation, business model definition and as a source of productivity is emphasized; and also the effects of technological capability on company’s success in formulation and execution of company’s business strategy. In an external socio-economic context, technology has a major impact for sustained development and wealth creation. Most managers are in the decisional situation in the high-tech businesses and use business and marketing strategies to obtain competitive advantage. The utilization of technology strategies as an original source for getting competitive advantage is a loss plan in their operational, mid-term and long-term planning and decisions. They should know engagement and bring substitutions of technology strategy into their high technology company, to acquire stable competitive advantages. Previously, only one side of the business took into account the strategy development and balancing trade-off and linkage between business and technology strategy was not well understood. Phaal and Muller (2009) provided a very effective tool for technology management: technology roadmaps. The use of roadmaps, especially technology roadmaps, is widely used throughout the industry and in government policies. They use the basic technology planning function: linking organizational strategic goals to research and development investment decisions while also communicating these linkages visually. Gerdsri et al. (2009) used technology road mapping (TRM) concepts, which integrate technology into business strategy for successful implementation of dynamics of TRM in initiation, development and integration stages. Furthermore, continuation of the enrichments of the TRM implementations using additional tools and techniques customized and facilitated the road mapping processes by integrating decision theory modes and technology forecasting techniques. Many of the researchers emphasized the three critical success factors (CSF): people, process and data in road mapping development (Gerdsri et al., 2007, 2009).

In the studies of the high-tech companies, to construct technology strategy map with objects of TBSC from literature reviews and empirical research, we should make this strategy map as a technology road map. The technology strategy map is a powerful communication tool that enables all employees to understand the technology and business strategy, and translate them into the actions which they can take to help the organizational technologically improvement succeed. The financial and customer objectives describe the outcomes the high technology company wants to achieve; objectives in the internal and technology and learning and growth perspectives describe how the organization intends to achieve these outcomes. On the other side, technology strategy map is a diagram that describes how an organization creates value by connecting strategic

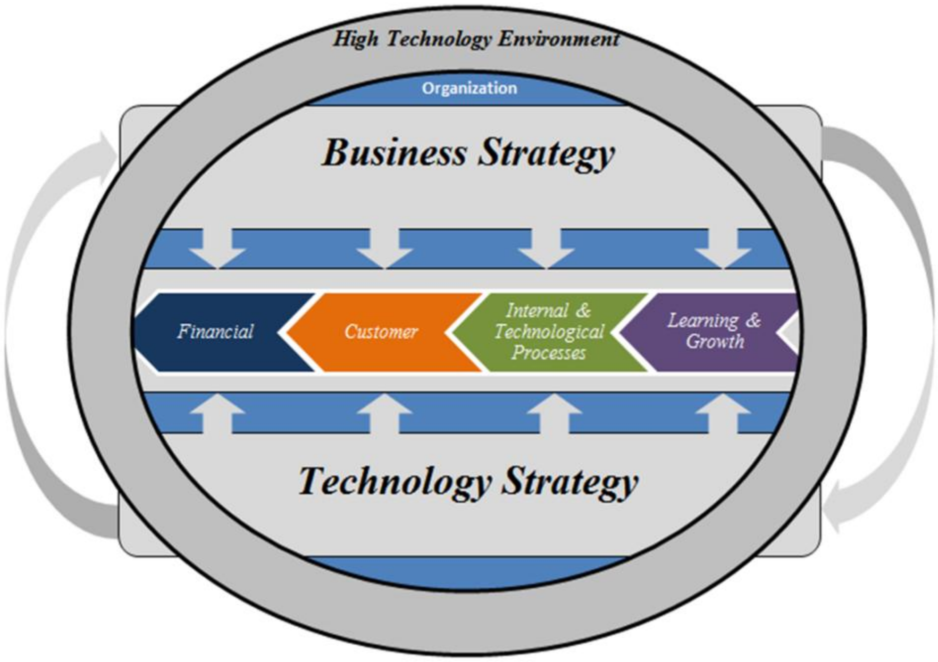

Figure 2. Proposed TBSC for SMOT in the high technology companies.

objectives in the explicit cause-and-effect relationship with one another in the four TBSC objectives. Technology strategy maps are a strategic part of the TBSC framework to describe a strategy for value creation. A simple techno-logy strategy map links strategic initiatives to achieve financial goals, while TSM shows causality among TBSC perspectives, but also it cannot correctly show the degree of causality and interrelations among strategic and technologic objects. The technology balanced scorecard (TBSC) approach helps high technology companies manage the implementation of their strategies. This mea-sures an organization's performance from four key perspectives: financial, customer, internal and techno-logical processes, and learning and growth. The TBSC approach logically links these four perspectives. Improve-ments in learning and growth perspective result in improved internal and technological processes. These results to create better products and services, therefore, higher customer satisfaction and higher market share, leading to enhance financial results for the organization (Norreklit, 2000; Kaplan and Norton, 2004; Marr and Schumia, 2003). Many of the critical high technology company's processes are external, which are ignored in traditional BSC; they are external technology process such as R&D collaboration, investment on joint-ventures and licensing. Thus, a good balanced scorecard should reflect all critical indices in the whole high technology environment without considering nature of indices for achieving convergences in both business strategy and technology strategy. Thus, in strategic management of technology we should consider both technology and business strategies. This is the reason why Iranian high technology companies which use BSC framework in their strategic management studies fail on maintaining high technology advantages. Technology balanced scorecard (TBSC) is composed by the integration of technology processes and internal business processes into internal and technological process perspective substitution of internal business process perspective in traditional BSC (Figure 2). TBSC identifies many cause-and-effect rela-tionships within the business and technology manage-ment. TBSC helps employees and managers appreciate the roles of employee and task as well as the importance of each result to the overall corporate effort.

Defining perspectives of proposed TBSC framework

High technology companies have the essential role in making crediting and wealth for nationals by high impacts on GDP rates. Additionally, high-tech companies acquire competitive advantage for nationals but there is no comprehensive framework for strategically managing technology in either micro or macro levels of strategic management. While companies have evolved to multifunctional strategic orientation where technology has a significant role, there still is no comprehensive frame of reference for strategic technology management. Therefore, absence of convergence between strategic management and technology management causes high-tech companies not to exploit profits of high technology industry. These are phenomena which almost all papers and researchers explain in both strategic management and technology management fields. By analyzing the strategic plans of 24 Iranian high-tech companies, this notion is bolded. Although this was notion cited previously, till now there are no comprehensive methods for achieving coherence among management of technology and business management. Generic process model (also called Gregory model) cannot correctly show technological trends (Table 1). Technology discontinuity is a big problem in high technology companies' studies, which befuddle companies in accepting the agreed critical technological objects that determine strategy ways for reaching organizational prosperities in high technology environments. Technology balanced scorecard is a good lens for looking at the high technology companies' performances from four perspectives. Proposed TBSC not only considers financial objects (for example, return on investments and cost leadership) but also considers non-financial objects (for example, technology innovation, enhancement of customers' satisfaction and retentions, new product development and HR development).

Financial perspective

Financial perspective defines the long-run objectives of high technology companies in today's turbulent environment. High technology companies should give right financial strategic decisions in their investments on the R&D projects, licensing technologies, buying or building etc. Selecting the best strategic decision for making prosperity and obtaining competitive advantage for high technology companies in the long-run terms depend on three critical objects: enhancing return on investments (ROI), cost leadership and risk management.

A high technology company that excels in many operational disciplines can still struggle if its product development decisions are flawed. Product management decisions within high technology companies need to be based in part on the estimated and measured return on product development expense. A clear, consistent practice for analyzing ROI and applying it in decision-making must be driven vertically and horizontally throughout the organization. Such a practice is an inherent requirement to realizing stable decision making and communicating product investment decisions.

If a high technology company decides to achieve a competitive advantage through cost leadership, it must attempt to lower its overall costs as much as possible. High technology invariably is a major weapon in achieving this goal. Costs are, of course, determined by a great many reasons; not all are technological. The cost of production, general and administration costs, the general efficiency of the organization, the state of the market, are all-important reasons. Technology affects costs in three ways: the cost of depreciation of machinery and equipment; the productivity of the production process; the design of the product. The first of these is not really under the individual control of the firm. If it happens to employ machinery that is rapidly becoming obsolescent, it will hardly be able to keep such machinery and still be a cost leader.

The efficiency of production itself is very much under the control of the firm. Employing the best available machinery and the best possible organization of production can make high technology company benefits from technology advantages; and also by using skilled workers and giving them incentives and opportunities to suggest improvements and see to improvement throughout the manufacturing process. By maintaining all the equipment in perfect shape and having a time-saving layout of the production facilities has been seen as improvement in production that leads to improved rates on ROI. Being in partnerships with reliable suppliers of components who deliver perfect quality just in time, thus obviating the need for quality control of components bought and the need for keeping large stocks helps companies to attain cost leadership among other companies. By designing of products for easy manufacturing and using all other appropriate ingredients of modern production management, the firm can increase productivity to the highest possible level. The financial perspective of the TBSC tries to sum up what has been applied in high technology companies and written in dozens of books and articles and has been developed over a good number of years (Womack et al., 1990; Bessant, 1991; Rhodes and Wield, 1994).

High technology companies may opt to share technology with partners abroad because collaborations give them more advantages to compensate for higher appropriate risk. A company may also perceive that partnership decreases competitive risk from poorly performing operations more than it increases the competitive risk from technology loss. This perception might occur because a partner has better country-specific knowledge, access to distribution and production factors, and complementary resources. At an extreme, a high technology company may be able to gain foreign cost and sales advantages only by producing abroad in some type of partnership. This is because a host government restricts imports and foreign-owned operations, or a company may fear economic and political risk more than technology appropriation risk and seek out a local partner who will share financial exposure.

Customers' perspective

Most managerial studies have shown an increasing realization of the importance of customers' retention and satisfaction in any business (Chabrow, 2003; Holloway, 2002; Needleman, 2003). If customers of high technology companies are not satisfied, they will eventually find other suppliers who will satisfy them. Because technological collaboration puts more synergies among high technology companies, partnership with our supplier is necessary. In the high technology companies, interaction and participation in the marketplace is the primary source of information regarding what the next set of product/service requirements might be. Interaction and participation in the marketplace is the touchstone of the organization in the marketplace. It yields the most precious information of how the used models can evolve once the next product feature is introduced. There is no market report or analysis that can provide the adequate and timely information on what product/service features to bring to market. Given that, systematically capturing and operating on market experience data is a strategic function. The gem of insight that sparks innovation, births the next feature set, and results in market leading products and services lies within this stream of experience data.

Poor performance from this perspective is thus a leading indicator of future decline, even though the current financial picture may look good. In developing indicators for satisfaction, customers should be analyzed in terms of kinds of customers and the kinds of processes for which a high technology company is providing a product or service to those customer groups (Ydstie, 2004; Erensal et al., 2006; Hofmann and Orr 2005; Reisman, 2005; Cho et al., 2012). Frequently considered TBSC objects from the customer perspective of high technology companies include enhancing market share, enhancing customer satisfaction and retention and partnerships with suppliers.

Internal and technological processes perspective

Objects and indicators based on this perspective allow the chief technology officers (CTOs) to evaluate how well their company is running, and whether its products and services conform to customers' requirements (the mission statement). For high technology companies, this is a strategic imperative as shrinking product cycle collapses the window of profitability and product success (Ydstie, 2004; Erensal et al., 2006). Customers are increasingly demanding on lead times, while operations teams are increasingly adverse to inventory. Forecast accuracy that can support or refute product plans for market penetration has become critical for product success. Internal and technological objects and indicators of high technology companies must accurately reflect processes most intimately with a high technology companies' unique missions. Most important TBSC objects for the internal and technological processes perspective include the technology innovation process, enhancing manufacturing process, new product development, Increased responsiveness, technology innovation, technology transferability, enhancing manufacturing process, new products development, developing R&D projects and teams, managing the product life cycle, strutting industry, academic and institutes and patent registration (Ernst, 2003; Song et al., 1997; Ydstie, 2004; Hofmann and Orr 2005; Liao, 2005; Reisman, 2005; Erensal et al., 2006; Cho et al., 2012).

Learning and growth perspective

This perspective includes relating leading edge technologies to the employees and corporate cultural attitudes related to learning technology leadership (Hofmann and Orr 2005). Kaplan and Norton (2000) emphasize that learning includes not only training, but also teamwork, ease of communication among workers, and technological tools (Song, 1997; Kaplan and Norton, 2000). In high technology companies, people, the only repository of knowledge, are the main resource and should be in a continuous learning phase. Appropriate objects can guide managers in focusing facilities where they can help the most. One such enabler of HR development, multi-skilled employees, has been proposed to be one of the preconditions for organizational responsiveness (Challis and Samson, 1996; Hofmann and Orr, 2005). Furthermore, this claim has been applied to a wide range of job classifications from assembly-line workers to engineers and technicians (Rogerson, 1993). In this paper, the multi-skilled worker (MSW) is defined to be a cross trained employees with productivity, flexibility, quality, and employee's morale. Frequently cited TBSC measures for the learning and growth perspective in the selected Iranian high technology companies emphasize HR developments (employee's education and skill levels, employee's turnover rates and multi-skilled employees); information systems capabilities (percentage of front-line employees with on-line access to technology information, percentage of technology processes with real-time feedback); employees' satisfaction and motivation; maintenance project management skills; enhancing creativity; learning technology leadership and improving organizational training effectiveness (Challis and Samson 1996; Burn and Szeto 2000; Sacristán et al., 2003; Ydstie, 2004; Hofmann and Orr, 2005). For composing technology strategy map, 240 personnel from 24 high technology companies were needed to answer correspondence question with 1-4 score. Scores depend upon the amount of strength each object has on the company's business strategy and technology strategy. The research was conducted by the contribution of top-manager, operational-managers, median managers, supervisors and co-workers in strategic management and chief technology officers (CTOs). Analyses of gathered results from 150 surveys are available in Table 2. The main process of this paper is exhibited in Figure 3.

Casualty analysis in the technology strategy maps using FCSM

Making FCM framework for technology strategy maps

A cognitive map (CM) is a directed digraph for showing causality between concepts in complex foundations; it was introduced by Axelrod (1976) in political complications. The fuzzy set theory is the most powerful tool for modelling uncertainty atmosphere; it was introduced by Zadeh (1975). His groundbreaking work led to the expansion of possibility theory. The theory of possibility is a cognitive process. The fuzzy set theory provides a mathematical model for evaluating the human inference process. As against probabilistic or statistical representations, the fuzzy set theory seeks to identify subjective reasoning and assign degrees of possibilities in reaching conclusions (Zadeh, 1975a; 1975b; 1975c).

A fuzzy cognitive Map (FCM) is a graphical representation, consisting of nodes indicating the most relevant factors of a decisional environment; and the links between these nodes representing the relationships between those factors. FCM is a modeling methodology for complex decision systems, which has originated from the combination of fuzzy logic and neural networks. A FCM describes the behavior of a system about concepts; each concept representing an entity, a state, available, or an attribution of the system (Kosko, 1986). FCMs have been applied in simulation, modeling of organizational strategies, support for strategic problem formulation and decision analysis, knowledge bases construction, managerial problems diagnosis, failure modes effects analysis, requirements analysis, systems requirements specification, urban design support, relationship management in airlines services and web-mining inference amplification (Rodriguez-Repiso et al., 2007). Kardars et al. (1998) used FCMs for strategic information system planning (SISP) and used FCM methodologies for considering causality relationships between 165 variables and 210 relationships in both information technology (IT) and business areas. Xiao et al. (2012) integrated FCM and fuzzy soft set for supplier selection problem based on risk evaluation, by considering dependent and feedback effect among criteria on the decision-making process. Carvalho (2013), focuses on FCM as tools to model and simulate complex social, economic and political systems on point of views; discussing the structure, the semantics and the possible use in the qualitative systems. Glykas (2012) presents the application of a fuzzy cognitive map (FCM) framework and its associated modelling and simulation tool to strategy maps (SMs) and resolve limits of SMs. He used combination of BSC and FCM for placement of different performance measurement scenarios using the fuzzy cognitive strategic (FCSM). His considered FCMs allow simulation of SMs as well as interconnection of performance measures in different SMs which enable the creation of SM hierarchies. Also Glykas (2013) elaborates on the application of fuzzy cognitive maps (FCMs) in strategy maps (SMs) in the business process performance measurement which was experimented in the two banking. Chytasa et al. (2011)'s works proposed a proactive balanced scorecard methodology (PBCSM). They proposed decision aid may serve as a back end to balanced scorecard development and implementation. Using FCMs, they used the proposed method to draw a causal representation of KPIs (Chytasa et al., 2011).

Current study follows Rodriguez-Repiso et al. (2007)'s FCM framework in causality relationships, which gives easier solution for composing and evaluating fuzzy cognitive strategy maps (FCSM). For making our FCM framework in current study, we define concepts as nodes; we use C_i for concept i (for i =1, 2,…, 23; we have 23

Table 2. Perspectives, objects and indicators of TBSC approach.

Perspective /Object	Indicators	Mean	SD	α
Financial				
(F1) Enhancing return on investment (ROI)	Return on technological investment	2.81	0.63	0.74
	Return on capital investment	3.13	0.25	
	Return on product development expense	3.21	0.24	
(F2) Cost leadership	Production reduced costs	2.14	0.35	0.65
	General and administration reduced costs	2.23	0.67	
(F3) Risk management	Technology ranking of products and process compared to competitors	2.86	0.14	0.77
Customer				
(C1) Enhanced Market Share	Number of new customers	3.22	0.15	0.70
	Brand price	2.84	0.24	
	Market share (%)	3.17	0.10	
(C2) Lift up customer satisfaction and retentions	Customer satisfaction index	2.68	0.46	0.63
	Decreased customer's complaints	2.49	0.78	
(C3) Partnerships with suppliers	Number of suppliers	2.20	0.33	0.65
	Number of outsourced projects	1.89	0.74	
Internal and Technological Processes				
(I1) Increased responsiveness	Product delivery reduced time	2.65	0.38	0.67
	Shortage response time	2.17	0.52	
	On-time deliveries	3.23	0.45	
(I2) Technology innovation	Number of explored technologies	3.42	0.08	0.78
(I3) Technology transferability	Number of licenses	3.58	0.24	0.75
	Number of Joint-ventures	2.47	0.50	
(I4) Enhancing manufacturing process	Field	3.65	0.13	0.66
	Decreased defect rates	3.24	0.25	
	Average time taken to manufacture orders	2.87	0.34	
	Setup time	2.89	0.34	
	Manufacturing down time	3.23	0.21	
(I5) New Products development	Number of new products/ services	2.76	0.36	0.72
(I6) Developing R&D projects and teams	Number of internal R&D projects	3.25	0.18	0.69
	Number of external R&D projects	2.74	0.64	
	The level of participation in problem definition	2.28	0.75	
	Percentage of projects based on teamwork	3.2	0.67	
(I7) Managing product life cycle	Product/process life cycle time	3.25	0.16	0.77
(I8) Strutting industry, academic and institutes	Number of new treaties	2.67	0.30	0.61
(I9) Patent registration	Number of newly registered patents	2.28	0.59	0.73
Learning and Growth				
(L1)Training leading-edge technologies	Number of scientists	3.24	0.26	0.79
	Leading-edge technology training (Hrs)	2.78	0.45	
	Number of multi-skilled employees	2.93	0.69	
(L2) HR development	Employee educational level	2.86	0.53	0.61
	Employee turnover rates	2.27	0.77	

Table 2. Contd.

(L3) Employees satisfaction and motivation	Employee satisfaction scores	2.35	0.30	0.75
	Number of motivational incentives	2.78	0.55	
	Percentage of employee suggestions implemented	2.91	0.47	
(L4) Information system capabilities	Percentage of front-line employees with on-line access to technology information	2.68	0.29	0.73
	Percentage of technological processes with real-time feedback	2.69	0.32	
(L5) Maintenance project management skills	Percentage of people engaged in decision-making	2.45	0.55	0.68
(L6) Enhance creativity	Number of accepted innovative proposal	2.38	0.41	0.73
	Number of new process improvement ideas generated	2.12	0.38	
	Number of suggestions per employee	3.46	0.58	
(L7) Learning technology leadership	Technology protection plans	3.76	0.56	0.69
	Number of technology acquainted	2.85	0.66	
(L8) Improve organizational training effectiveness	Index of training effectiveness	3.57	0.11	0.71

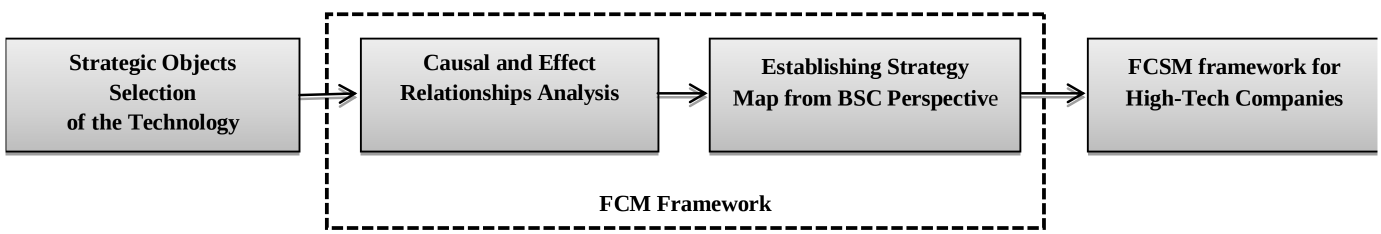

Figure 3. FCSM framework process for the Iranian high-tech companies strategic planning.

objects from four TBSC perspectives) (Pelaez and Bowles, 1995; Tsadiras, 2008).

To determine the strength between two concepts (for example, i and j seen in W_{ij}), we should first define sign of the strength between concepts. If an increase in one concept causes increase in amounts of another concept, we conclude there is positive relationship between the two concepts. When an increase for the number of one concept causes decrease in amounts of another concept, consequently, we conclude there is negative relation between the two concepts. If there is no logical or empirical relation between two concepts, we infer there is no relationship between the mentioned concepts.

According to the above subjects, we concluded that the amounts of these relationships in FCM can be positive or negative or zero defined as follows:

$$\begin{cases} W_{ij} > 0 & \text{Describes a positive casual relationship} \\ W_{ij} < 0 & \text{Describes a negative casual relationship} \\ W_{ij} = 0 & \text{Without any casual relationship} \end{cases} \quad (1)$$

For example, in the current study, it is obvious that all the relationships in our technology strategy map have positive relationships with other objects. Increase in amounts of 'HR development (L2)' activities causes increase in 'training leading-edge technologies (L1)' (Figure 4). So we conclude there is a positive relationship between 'L1' and 'L2' (Rodriguez-Repiso et al., 2007; Kosko, 1986). For obtaining the amount of these relationships, we use Rodriguez-Repiso et al.'s methodology, based on four matrixes consisting of the initial matrix of

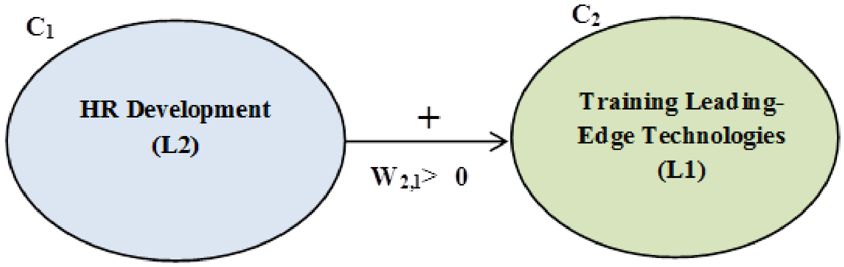

Figure 4. Sample of relationships in strategic management of technology implementation.

concepts (IMC), fuzzified matrix of concepts (FMC), strength of relationships matrix of concepts (SRMC) and final matrix of concepts (FMS).

In the first step, we compose the initial matrix of concepts (IMC). IMC is created by collecting empirical data from 24 high-tech companies, which was conducted by a contribution of top-manager, operational-managers, planet managers, supervisors, co-workers and chief technology officers (CTOs). IMC is made by those who have been educated in the strategic management of technology practices and have applied strategic technology improvement tool sets in their companies. Total objects rolled in strategic management of technology in the high technology companies according to the four TBSC perspectives are 23 objects. Finally, we concluded all empirical data from each high technology companies are in one column according to CTO which describes a high technology situation from four TBSC perspectives. $O_{i,j}$ describes elements in row i and column j according to CTOs suggestion of jth high technology company based on empirical results of ith object. Also we show row i in the corresponding matrix with V_i (Rodriguez-Repiso et al., 2007).

In the next step, we compose fuzzified matrix of concepts (FMC) by using data from Table 3, and translate this matrix to a fuzzy matrix by using Likert scale (VH=9, H=7, M=5, L=3, VL=1) and the following formulas:

$\text{Max}(O\ iq) \Rightarrow X_i(O\ iq)=1$ and $\text{Min}(O_{ip}) \Rightarrow Xi(O_{ip})=1$; for

p,q=1, 2, 3,…, 24; i=1,2,…,23

$$X\_i\ (O''\ ij'') = (O''iq''\ - \text{Min}(O''ip''\ ))/(\text{Max}(O''iq''\ ) - \quad (2)$$

It seems every row illustrates the intense of each object in our empirical research according to CTOs suggestion which contributed to SMOT processes and evaluations based on empirical data (Table 4). In some studies similar to this study, it is difficult to assign a numerical score for each object from SMOT between 0 and 100. For facilitating this work, we changed Rodriguez-Repiso's algorithms using linguistically variables standby numerical scale according to the collected empirical research, without missing main FCM concept, which is much closer to the fuzzy concept of FCM (Rodriguez-Repiso et al., 2007; Kosko, 1986). In the third step, we need to compute adjacency of two concepts C_i and C_j using two kinds of formulations. If two concepts, C_i and C_j have a direct positive relationship we use $X_1 (V j) - X_2 (V j)$ for distance among the two concepts; but if two concepts have reverse relationship, we use. $X_1 (V_j) – (1 - X_2 (V_j)$. Subsequently, by defining two types of formulations, there comes another two formulations for computing distance, using absolute assignment for the two mentioned formulations and we obtain $d_j = | X_1 (V_j) - X_2 (V_j))|$ for direct relations and $d_j = | X_1 (V_j) – (1 - X_2 (V_j))|$ for diverse relations. According to the above subjects another variable should be defined as AD as follows:

$$AD = \frac{\sum_{j=1}^{m} dj}{m}$$

At last, adjacency of the two concepts rows (Concepts) defined with S determines:

$$S = 1 - AD.$$

Some computed values between concepts (Table 5) might be impossible in technology strategy maps of high technology companies and do not exist empirically; thus should be ignored. Also mathematics computes acquire this deleted relationship. In doing this work, we obtain final matrix of concepts (FMS) as seen in Table 6.

Casualty analysis in the TSM

Proposed FCSM framework for technology strategy maps of high technology companies improves organizational

Table 3. Empirical data collected from 24 high technology companies (IMC).

TBSC Object	High tech company																							
	HT_1	HT_2	HT_3	HT_4	HT_5	HT_6	HT_7	HT_8	HT_9	HT_{10}	HT_{11}	HT_{12}	HT_{13}	HT_{14}	HT_{15}	HT_{16}	HT_{17}	HT_{18}	HT_{19}	HT_{20}	HT_{21}	HT_{22}	HT_{23}	HT_{24}
F1	VH	H	M	VH	VH	VH	H	VH	VH	M	H	VH	VH	VH	VH	M	H	H	L	M	VH	VH	VH	VH
F2	VH	H	H	H	H	H	VH	M	H	VH	VH	M	M	VH	H	M	M	M	H	VH	M	M	H	VL
F3	M	L	H	L	L	H	L	L	VL	L	L	L	L	L	VH	VH	H	H	VH	VL	M	H	VH	M
C1	M	H	VH	L	M	L	H	L	H	M	L	H	VH	H	H	VH	H	M	L	H	L	M	L	M
C2	VH	H	H	VH	H	H	M	H	VH	H	VH	M	H	VH	VH	H	M	L	M	VL	M	M	VL	H
C3	H	H	M	VH	VH	VL	H	VH	H	VH	VH	H	H	VH	H	L	M	M	M	H	M	H	M	VH
I1	H	VH	M	H	H	VH	VL	M	H	L	VH	M	M	M	L	VH	H	M	L	L	H	M	L	L
I2	VH	H	M	M	L	H	M	M	H	H	VL	L	M	M	H	H	M	VH	VH	H	H	VH	H	VH
I3	VH	M	H	VL	VL	L	M	M	H	H	M	H	L	VL	VH	M	H	L	L	L	VH	L	VH	VH
I4	M	VH	H	M	M	M	H	VH	M	M	H	VL	VH	H	M	VH	VH	VH	H	VH	VH	M	H	VH
I5	M	M	L	VH	H	M	L	L	H	M	L	L	VH	M	H	VL	VL	L	M	M	H	H	M	H
I6	VH	H	H	M	H	VH	H	VH	M	H	VH	L	L	L	VH	VH	H	H	VH	VL	M	H	VH	M
I7	VL	H	H	M	VH	VH	VL	H	VH	H	VH	VH	H	H	VH	H	L	M	M	M	H	M	H	M
I8	L	L	L	H	M	M	H	VH	VH	VH	VL	H	VH	H	VH	VH	H	H	VH	H	L	M	M	M
I9	M	VH	VL	M	M	H	VH	L	VH	VH	VH	H	M	M	M	VH	H	L	M	H	M	M	VL	L
L1	H	H	M	VH	VH	VL	H	VH	H	VH	VH	H	H	VH	H	L	M	M	M	H	M	H	M	VH
L2	H	M	L	H	H	H	VH	M	L	VH	H	H	VH	H	H	M	H	VH	H	VH	M	H	M	L
L3	M	L	H	H	L	VH	VH	M	VH	L	VH	M	M	M	M	H	M	VH	VH	L	M	M	M	L
L4	VH	VH	VH	M	H	H	L	M	VH	VH	VH	VH	VL	H	H	M	VH	VH	VL	H	VH	H	VH	VH
L5	M	VH	H	M	M	M	H	VH	M	M	H	VL	L	L	L	H	M	M	H	VH	VH	VH	VL	H
L6	VH	VL	M	M	H	VH	L	VH	VH	VH	H	M	L	L	H	L	L	VL	L	L	L	L	M	M
L7	H	M	VH	VH	VL	H	VH	H	VH	VH	H	H	L	M	L	H	L	H	M	L	H	VH	M	L
L8	M	M	H	M	VH	VH	VH	M	M	M	M	H	M	VH	VH	M	L	L	M	VH	VH	M	H	L

Notation : VH is abbreviations of very high influences; **H** is abbreviations of high influence; M is abbreviations of medium influence; **L** is abbreviations of very low influences; and **VL** used for very low influences.

strategies in both business and technology areas. Technology strategy map conquers balanced scorecard (BSC) traditional defaults discussed throughout the literature such as need for fuzziness in causal relationships, dynamic relationships and interactions among strategic

Table 4. The fuzzified matrix of concepts (FMC).

TBSC Object	High tech company																							
	HT1	HT2	HT3	HT4	HT5	HT6	HT7	HT8	HT9	HT10	HT11	HT12	HT13	HT14	HT15	HT16	HT17	HT18	HT19	HT20	HT21	HT22	HT23	HT24
F1	1.00	0.67	0.33	1.00	1.00	1.00	0.67	1.00	1.00	0.33	0.67	1.00	1.00	1.00	1.00	0.33	0.67	0.67	0.00	0.33	1.00	1.00	1.00	1.00
F2	1.00	0.75	0.75	0.75	0.75	0.75	1.00	0.50	0.75	1.00	1.00	0.50	0.50	1.00	0.75	0.50	0.50	0.50	0.75	1.00	0.50	0.50	0.75	0.00
F3	0.50	0.25	0.75	0.25	0.25	0.75	0.25	0.25	0.00	0.25	0.25	0.25	0.25	0.25	1.00	1.00	0.75	0.75	1.00	0.00	0.50	0.75	1.00	0.50
C1	0.33	0.67	1.00	0.00	0.33	0.00	0.67	0.00	0.67	0.33	0.00	0.67	1.00	0.67	0.67	1.00	0.67	0.33	0.00	0.67	0.00	0.33	0.00	0.33
C2	1.00	0.75	0.75	1.00	0.75	0.75	0.50	0.75	1.00	0.75	1.00	0.50	0.75	1.00	1.00	0.75	0.50	0.25	0.50	0.00	0.50	0.50	0.00	0.75
C3	0.75	0.75	0.50	1.00	1.00	0.00	0.75	1.00	0.75	1.00	1.00	0.75	0.75	1.00	0.75	0.25	0.50	0.50	0.50	0.75	0.50	0.75	0.50	1.00
I1	0.75	1.00	0.50	0.75	0.75	1.00	0.00	0.50	0.75	0.25	1.00	0.50	0.50	0.50	0.25	1.00	0.75	0.50	0.25	0.25	0.75	0.50	0.25	0.25
I2	1.00	0.75	0.50	0.50	0.25	0.75	0.50	0.50	0.75	0.75	0.00	0.25	0.50	0.50	0.75	0.75	0.50	1.00	1.00	0.75	0.75	1.00	0.75	1.00
I3	1.00	0.50	0.75	0.00	0.00	0.25	0.50	0.50	0.75	0.75	0.50	0.75	0.25	0.00	1.00	0.50	0.75	0.25	0.25	0.25	1.00	0.25	1.00	1.00
I4	0.50	1.00	0.75	0.50	0.50	0.50	0.75	1.00	0.50	0.50	0.75	0.00	1.00	0.75	0.50	1.00	1.00	1.00	0.75	1.00	1.00	0.50	0.75	1.00
I5	0.50	0.50	0.25	1.00	0.75	0.50	0.25	0.25	0.75	0.50	0.25	0.25	1.00	0.50	0.75	0.00	0.00	0.25	0.50	0.50	0.75	0.75	0.50	0.75
I6	1.00	0.75	0.75	0.50	0.75	1.00	0.75	1.00	0.50	0.75	1.00	0.25	0.25	0.25	1.00	1.00	0.75	0.75	1.00	0.00	0.50	0.75	1.00	0.50
I7	0.00	0.75	0.75	0.50	1.00	1.00	0.00	0.75	1.00	0.75	1.00	1.00	0.75	0.75	1.00	0.75	0.25	0.50	0.50	0.50	0.75	0.50	0.75	0.50
I8	0.25	0.25	0.25	0.75	0.50	0.50	0.75	1.00	1.00	1.00	0.00	0.75	1.00	0.75	1.00	1.00	0.75	0.75	1.00	0.75	0.25	0.50	0.50	0.50
I9	0.50	1.00	0.00	0.50	0.50	0.75	1.00	0.25	1.00	1.00	1.00	0.75	0.50	0.50	0.50	1.00	0.75	0.25	0.50	0.75	0.50	0.50	0.00	0.25
L1	0.75	0.75	0.50	1.00	1.00	0.00	0.75	1.00	0.75	1.00	1.00	0.75	0.75	1.00	0.75	0.25	0.50	0.50	0.50	0.75	0.50	0.75	0.50	1.00
L2	0.67	0.33	0.00	0.67	0.67	0.67	1.00	0.33	0.00	1.00	0.67	0.67	1.00	0.67	0.67	0.33	0.67	1.00	0.67	1.00	0.33	0.67	0.33	0.00
L3	0.33	0.00	0.67	0.67	0.00	1.00	1.00	0.33	1.00	0.00	1.00	0.33	0.33	0.33	0.33	0.67	0.33	1.00	1.00	0.00	0.33	0.33	0.33	0.00
L4	1.00	1.00	1.00	0.50	0.75	0.75	0.25	0.50	1.00	1.00	1.00	1.00	0.00	0.75	0.75	0.50	1.00	1.00	0.00	0.75	1.00	0.75	1.00	1.00
L5	0.50	1.00	0.75	0.50	0.50	0.50	0.75	1.00	0.50	0.50	0.75	0.00	0.25	0.25	0.25	0.75	0.50	0.50	0.75	1.00	1.00	1.00	0.00	0.75
L6	1.00	0.00	0.50	0.50	0.75	1.00	0.25	1.00	1.00	1.00	0.75	0.50	0.25	0.25	0.75	0.25	0.25	0.00	0.25	0.25	0.25	0.25	0.50	0.50
L7	0.75	0.50	1.00	1.00	0.00	0.75	1.00	0.75	1.00	1.00	0.75	0.75	0.25	0.50	0.25	0.75	0.25	0.75	0.50	0.25	0.75	1.00	0.50	0.25
L8	0.33	0.33	0.67	0.33	1.00	1.00	1.00	0.33	0.33	0.33	0.33	0.67	0.33	1.00	1.00	0.33	0.00	0.00	0.33	1.00	1.00	0.33	0.67	0.00

objects.

The present, research addresses the problems of the balanced scorecard by using the soft computing characteristics of fuzzy cognitive maps (FCMs). FCSMs connect such objects as enhancing customers' satisfaction and retention, risk management, enhancing process management, new product development, technology leaderships, innovation, human resources, information system capabilities and learning with one another in one graphical representation. Technology strategy mapping helps greatly in describing

Table 5. The strength of relationships matrix of concepts (SRMC).

TBSC Object	F1	F2	F3	C1	C2	C3	I1	I2	I3	I4	I5	I6	I7	I8	I9	L1	L2	L3	L4	L5	L6	L7	L8
F1		0.64	0.52	0.51	0.71	0.74	0.63	0.64	0.64	0.63	0.65	0.66	0.69	0.63	0.54	0.74	0.58	0.47	0.71	0.57	0.63	0.63	0.61
F2	0.64		0.58	0.57	0.78	0.78	0.72	0.73	0.63	0.68	0.64	0.73	0.72	0.67	0.75	0.78	0.76	0.66	0.71	0.67	0.68	0.71	0.71
F3	0.52	0.58		0.59	0.59	0.49	0.64	0.71	0.67	0.61	0.64	0.79	0.59	0.65	0.58	0.49	0.60	0.67	0.56	0.63	0.59	0.60	0.60
C1	0.51	0.57	0.59		0.60	0.58	0.62	0.59	0.61	0.60	0.61	0.51	0.57	0.67	0.67	0.58	0.60	0.54	0.51	0.58	0.52	0.55	0.60
C2	0.71	0.78	0.59	0.60		0.77	0.73	0.68	0.66	0.63	0.69	0.74	0.77	0.66	0.72	0.77	0.60	0.61	0.66	0.66	0.71	0.70	0.58
C3	0.74	0.78	0.49	0.58	0.77		0.65	0.68	0.61	0.67	0.71	0.66	0.71	0.70	0.68	1.00	0.68	0.51	0.68	0.66	0.67	0.68	0.60
I1	0.63	0.72	0.64	0.62	0.73	0.65		0.66	0.61	0.65	0.67	0.70	0.73	0.59	0.76	0.65	0.61	0.67	0.66	0.68	0.69	0.70	0.60
I2	0.64	0.73	0.71	0.59	0.68	0.68	0.66		0.69	0.72	0.70	0.73	0.66	0.69	0.65	0.68	0.64	0.61	0.71	0.71	0.61	0.69	0.57
I3	0.64	0.63	0.67	0.61	0.66	0.61	0.61	0.69		0.59	0.61	0.67	0.61	0.56	0.58	0.61	0.52	0.54	0.69	0.60	0.68	0.65	0.61
I4	0.63	0.68	0.61	0.60	0.63	0.67	0.65	0.72	0.59		0.63	0.70	0.65	0.70	0.66	0.67	0.65	0.56	0.68	0.82	0.52	0.59	0.58
I5	0.65	0.64	0.64	0.61	0.69	0.71	0.67	0.70	0.61	0.63		0.57	0.67	0.66	0.64	0.71	0.66	0.55	0.57	0.64	0.67	0.64	0.65
I6	0.66	0.73	0.79	0.51	0.74	0.66	0.70	0.73	0.67	0.70	0.57		0.70	0.67	0.65	0.66	0.59	0.66	0.67	0.71	0.70	0.67	0.56
I7	0.69	0.72	0.59	0.57	0.77	0.71	0.73	0.66	0.61	0.65	0.67	0.70		0.68	0.68	0.71	0.58	0.59	0.70	0.61	0.69	0.68	0.67
I8	0.63	0.67	0.65	0.67	0.66	0.70	0.59	0.69	0.56	0.70	0.66	0.67	0.68		0.71	0.70	0.72	0.60	0.56	0.60	0.64	0.65	0.57
I9	0.54	0.75	0.58	0.67	0.72	0.68	0.76	0.65	0.58	0.66	0.64	0.65	0.68	0.71		0.68	0.73	0.65	0.65	0.69	0.64	0.71	0.61
L1	0.74	0.78	0.49	0.58	0.77	1.00	0.65	0.68	0.61	0.67	0.71	0.66	0.71	0.70	0.68		0.68	0.51	0.68	0.66	0.67	0.68	0.60
L2	0.58	0.76	0.60	0.60	0.60	0.68	0.61	0.64	0.52	0.65	0.66	0.59	0.58	0.72	0.73	0.68		0.64	0.59	0.60	0.60	0.65	0.67
L3	0.47	0.66	0.67	0.54	0.61	0.51	0.67	0.61	0.54	0.56	0.55	0.66	0.59	0.60	0.65	0.51	0.64		0.49	0.60	0.65	0.71	0.61
L4	0.71	0.71	0.56	0.51	0.66	0.68	0.66	0.71	0.69	0.68	0.57	0.67	0.70	0.56	0.65	0.68	0.59	0.49		0.60	0.64	0.65	0.55
L5	0.57	0.67	0.63	0.58	0.66	0.66	0.68	0.71	0.60	0.82	0.64	0.71	0.61	0.60	0.69	0.66	0.60	0.60	0.60		0.59	0.69	0.59
L6	0.63	0.68	0.59	0.52	0.71	0.67	0.69	0.61	0.68	0.52	0.67	0.70	0.69	0.64	0.64	0.67	0.60	0.65	0.64	0.59		0.68	0.64
L7	0.63	0.71	0.60	0.55	0.70	0.68	0.70	0.69	0.65	0.59	0.64	0.67	0.68	0.65	0.71	0.68	0.65	0.71	0.65	0.69	0.68		0.58
L8	0.61	0.71	0.60	0.60	0.58	0.60	0.60	0.57	0.61	0.58	0.65	0.56	0.67	0.57	0.61	0.60	0.67	0.61	0.55	0.59	0.64	0.58	

the technology strategy and communicating this strategy among executives and their employees. In this way, alignment can be created around the strategy, which makes a successful implementation of the strategy easier. We should bear in mind that often, the implementation of a constructed strategy is the biggest challenge. In the strategy-focused organization, Kaplan and Norton transformed their balanced scorecard,

Table 6. The final matrix of concepts (FMS).

TBSC Object	F1	F2	F3	C1	C2	C3	I1	I2	I3	I4	I5	I6	I7	I8	I9	L1	L2	L3	L4	L5	L6	L7	L8
F1																							
F2	0.64																						
F3	0.52																						
C1	0.51	0.57	0.59																				
C2		0.78		0.60																			
C3			0.49	0.58																			
I1					0.73																		
I2		0.73		0.59	0.68		0.66				0.70												
I3						0.61							0.61										
I4									0.59				0.65										
I5				0.61																			
I6									0.67														
I7				0.57							0.67												
I8										0.70	0.66	0.67				0.70							
I9								0.65			0.64												
L1																						0.68	0.60
L2																0.68		0.64		0.60	0.60		0.67
L3														0.60					0.49				0.61
L4										0.68													
L5												0.71		0.60					0.60				
L6																				0.59			
L7							0.70								0.71								
L8															0.61				0.55			0.58	

introduced in 1992 in the Harvard business review as a performance measurement system, to a strategic management system. A lot of that transformation was done in introducing the so-called strategy map. In our proposed FCSM all of the information about high technology companies is contained in one page; this enables relatively easy strategic communication through four FCSM perspectives: financial; customer; internal;

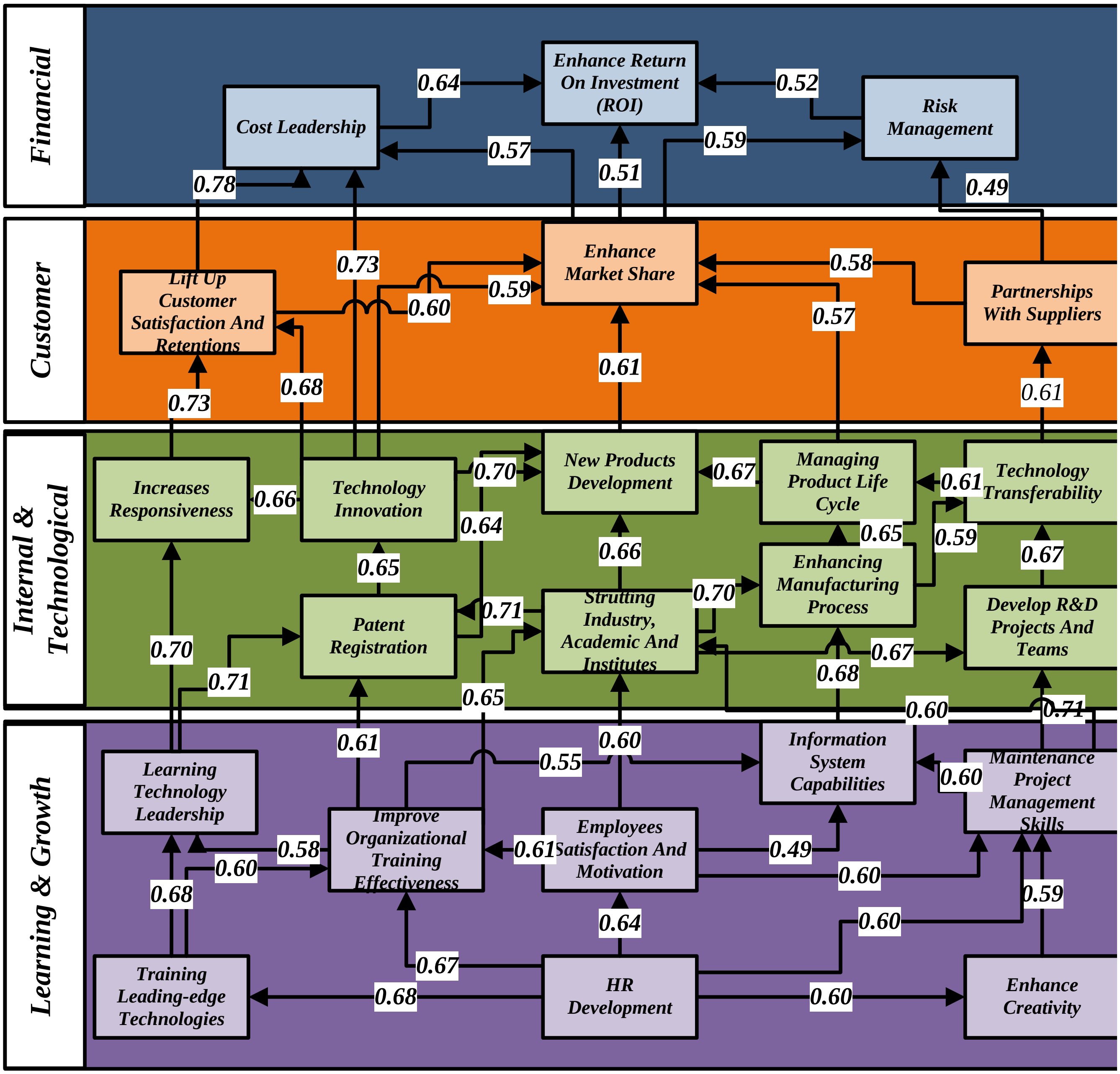

Figure 5. Proposed FCSM for the high technology companies.

learning and growth. Financial perspective of FCSM looks at creating long-terms shareholders' value and builds from a productivity strategy of improving cost structure, asset utilization and a growth strategy of expanding opportunities and enhancing customers' value. Strategic improvement is supported by price, quality, availability, selection, functionality, service, partnership and branding. From an internal and technological perspective, operations and technology management processes help to create product and service attributes while innovation, regulatory and social processes help with relationships and image. All of these processes are supported by the allocation of human, information and organizational capital, which comprise company culture, leadership, alignment and teamwork. Finally, cause and effect relationships are described by connecting arrows (Figure 5).

Conclusion

In this paper, the results of the strategic management of technology (SMOT) practices in high technology companies' context are concluded from four perspectives of TBSC. Proposed TBSC is considered as a framework for technology management in the Iranian high technology companies. This paper also presented an application of FCMs in TSM and proposed the FCSM by considering 23 objects and 49 relationships between these from four TBSC perspectives in the high technology companies' context. In an increasingly complex and dynamic environment, practitioners in high technology companies are facing a challenge on how to strategically manage technology to sustain the company's competitiveness. The main theoretical contribution of the research is composing the new framework for reaching the determined goals which technology management from TBSC approach. TSM framework unites strategic management, organizational management and technology management viewpoints to enterprise management, and enhances knowledge in strategic technology management. It was also shown the important role of fuzzy cognitive maps in causality relationship analysis between TBSC objects in presented technology strategy map. A FCSM not only shows how technology and business strategies integrate into one cognitive map, but also shows causality relationships and degrees of interrelations between objects in both strategic and technology management. Also a FCSM shows interrelations among SMOT objects by jointed-cycles and paths in the high technology environment. Current study provides a context for future researchers to work on the SMOT by considering more objects and interrelationships, using data mining and another statistical analysis technique.

Conflict of interest

Author have not declared any conflict of interest

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Ranking DMUs based on efficiency stability

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Decision-making process is to find the best option from all of the feasible alternatives. Considering the efficiency interval, efficiency scores from optimistic and pessimistic points of view, all the possible evaluations can be illustrated. Therefore, Interval DEA models can be helpful for a decision maker needs all those possible efficiency values that reflect different perspectives. The mentioned upper and lower bound of efficiency interval is obtained from the optimistic and pessimistic viewpoints. As a matter of fact, it can be propounded that in assessing DMUs considering the mere optimistic efficiency score is not a acceptable criterion for ranking units and performance evaluation of them. Since, in the event that an entity has gain a high efficiency with a great risk it will not certainly have priority to a unit with relatively balancing efficiency, suitable confidence interval and a low risk. In this paper considering the above issues a method for ranking units based on efficiency intervals is presented. With an application the clarity of the proposed procedure will be demonstrated.

Key words: Data envelopment analysis, interval DEA models, ranking.

INTRODUCTION

Data envelopment analysis (DEA) is a non parametric technique for measuring and evaluating the relative efficiency of decision making units (DMUs) with multiple inputs and outputs. In Classical DEA models inputs have to be minimized, outputs have to be maximized and units are assumed to operate under similar conditions. In accordance to the information about exiting data, DEA technique can estimate the efficiency frontier. If a DMU locates onto this frontier it is evaluated with the efficiency score of one and thus it is referred to as an efficient unit; otherwise if the correspondence efficiency score is less than one an it is referred to as an inefficient unit. While considering DEA technique it is possible to find targets and benchmark units for inefficient DMUs. In DEA the efficiency measure for a DMU is assumed as the maximum ratio of weighted sum of outputs to that of inputs. This maximum ratio, the efficiency value, is calculated from the optimistic viewpoint. Schaffnit et al. (1997) provided a paper in which a best practice analysis of a large Canadian bank has been presented. In their paper, Schaffnit et al, (1997), based on standard transaction and maintenance times, used DEA AR models with output multiplier constraints. Also a model which adds constraints on the input multipliers is used to find the cost efficient branches, and

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estimate “allocative” efficiency. Azizi (2011) in his paper confirms that the traditional DEA determines the best efficiency score based on which, DMUs are classified into optimistic efficient or optimistic non-efficient units, and the DEA-efficient DMUs determine the efficiency frontier. There is a comparable approach which uses the concept of inefficiency frontier for determining the worst relative efficiency score. In his paper, considered an integration of both efficiencies in the form of an interval. He emphesized that the obtained efficiency interval provides the decision maker with all the possible values of efficiency, which reflect various perspectives. Wang et al. (2007) stated that the worst relative efficiencies can be utilized for measuring the worst performances of DMUs, while efficiencies are measured within the range of greater than or equal to one. In their paper the efficiencies, corresponding to each DMU, are measured as an interval, whose upper bound is set to one and the lower bound is determined through introducing a virtual anti-ideal DMU. We discuss that we can have efficiency intervals consisting of the maximum and minimum ratios of weighted sum of outputs to that of inputs. In other words, the upper bound of efficiency interval is the efficicncy obtained from the optimistic view-point based on the same concept as in the conventional DEA. The correspondance lower bound is obtained from the pessimistic viewpoint by focusing on the inferior inputs and outputs. The great feature of considering both opti-mistic and pessimistic efficieny scores is that the efficiency interval can illustrate all the possible evaluations from various viewpoints.

In literature finding the lower bound of efficicny has been dealt with. jahanshahloo et al. (2010) provided a model for deriving the lower bound of efficiency. Entani and Tanaka (2006), while considering both the optimistic and the pessimistic viewpoints, proposed a DEA model with interval efficiencies and by adjusting corresponding given inputs and outputs they have improved the efficiency interval of a DMU. Entani and Tanaka (2006), for im-proving the lower bound of efficiency interval, have defined different target points for different DMUs. As they stated while the other presented interval DEA models cannot be used to measure the interval efficiency of a DMU with crisp data and can merely be utilized for interval data, their DEA model can be used for measuring the interval efficiency of a DMU with crisp, interval, fuzzy data or even with the mixture of those. In their paper Wang et al. (2005) studied how to conduct efficiency assessment using data envelopment analysis in interval and/or fuzzy input–output circumstances. The proposed interval DEA models are developed to measure the lower and upper bounds of the best relative efficiency of each DMU with interval input and output data. As discussed the obtained intervals are different from that formed by the worst and the best relative efficiencies of each DMU and this is a significant feature of the proposed model with which the models become more applicable.

Here the aim is to determine the upper and lower bounds of efficiency for ranking DMUs. Since, investigation and consideration of all accomplishment and failure factors can result in alternatives that help in decision making. As a matter of fact it can be propounded that in assessing DMUs considering the mere optimistic efficiency scores is not a sufficient criterion for performance evaluation and ranking of units. Since, in the event that an entity has gained a high efficiency score with a great risk it will not certainly have a priority to an entity with relatively balancing efficiency score, suitable confidence interval and a low risk. Thus, for ranking entities both efficiency and stability should be considered.

The paper unfolds as follows: First, some preliminaries about lower and upper efficiency bounds will be discussed; then the procedure for ranking units, considering these bounds, will be explained and the result are gathered and examined. Section 4 concludes tha paper.

Application

In this competitive world, considering a factor directly influenced the competition, has a fundamental importance. Doubtlessly, taking a reliable action with an acceptable assurance interval is better than that with a high risk. What will be discussed here is ranking DMUs based on stability interval, from the optimistic and pessimistic viewpoints, in efficiency evaluation. Thus, at first some preliminaries about the lower and upper efficiency bounds and then ranking due to these efficiency bounds will be discussed.

Preliminaries

The relative efficiency can be acquired from various viewpoints. In this section we have briefly reviewed the Interval DEA model which yields the efficiency interval, (Wang et al., 2005). By efficiency interval correspondance upper and lower bounds are considered. These intervals are acquired by solving two optimization problems. While the efficiency of a DMU is calculated from the optimistic viewpoint relative ratio is maximized with respect to input and output of the other DMUs. When optimistic viewpoint is considered, corresponding relative ratio of the under evaluation unit is minimized. As stated in jahanshahloo et al. (2010) evaluations from the optimistic and pessimistic viewpoints, respectively, will yield the upper and lower bounds of efficiency interval. The conventional DEA is regarded as the evaluation from the optimistic viewpoint; the upper bound of efficiency interval for DMU_o can be obtained through solving conventional model, called

CCR, Charnes et al. (1978). Considering the original CCR model formulated as a fractional programming problem, the problem to acquire the upper bound of efficiency interval is formulated as follows:

$$\begin{aligned} \max \quad & \frac{U^tY_o/V^tX_o}{Max\{U^tY_j/V^tX_j, \quad j=1,\dots,n\}} \\ s.t. \quad & V \geq 0, \\ & U \geq 0, \end{aligned} \tag{1}$$

where x_j and y_j are the given input and output vectors of DMU_j, j=1,...,n, are all semipositive. Also v and u are the input and output weight vectors. Thus, there exists n $DMUs$ with m inputs and s outputs. It should be noted that the denominator in (1) plays an important role of normalizing efficiency value. The ratio of weighted sum of outputs to that of inputs for DMU_o is compared to the maximum ratio of all $DMUs$. In CCR model, the ratios of weighted sum of outputs to that of inputs for all $DMUs$ are constrained to be less than or equals one for normalization. The linear counterpart of (1) is the following model. Thus, the upper bound of efficiency interval is obtained through solving the basic DEA model denoted as the following LP problem:

$$\begin{aligned} \max \quad & U^tY_o \\ s.t. \quad & V^tX_o = 1, \\ & U^tY_j - V^tX_j \leq 0, \quad j=1,\dots,n, \\ & U \geq 0, \quad V \geq 0. \end{aligned} \tag{2}$$

One issue needs to be mentioned here is that from among n units, there exists one unit with the efficiency score of 1 which guarantees that model (1) provides relative efficiency. But this is not true for the case of obtaining the lower bound of efficiency (pessimistic viewpoint). Therefore, as Entani et al. (2006) have presented, by minimizing the objective function in (1) with respect to the weight variables, the lower bound of efficiency interval is obtained by following problem:

$$\begin{aligned} \min \quad & \frac{U^tY_o/V^tX_o}{Max\{U^tY_j/V^tX_j \mid j=1,\dots,n\}} \\ s.t. \quad & V \geq 0 \\ & U \geq 0, \end{aligned} \tag{3}$$

As stated in Entani et al. (2006), the optimal objective value of this model is obtained with inferior inputs and outputs of DMU_o. Therefore, it can be said that it is the evaluation from the pessimistic viewpoint. The efficiency interval denoted as $[\theta_o^{l*}, \theta_o^{u*}]$ illustrates all the possible evaluations from various viewpoints.

Another model which was proposed by Jahanshahloo et al. (2010) for assessment of the lower bound of efficiency is as follows which correct the shortcoming of the model proposed by Entani Et al. (2006). In their paper they have discussed that there is no guarantee to have relative efficiency, thus they have suggested the following model:

$$\begin{aligned} \min \quad & U^tY_o \\ s.t. \quad & V^tX_o = 1, \\ & U^tY_j - V^tX_j \leq 0, \quad j=1,\dots,n, j \neq o \\ & U^tY_p - V^tX_p = 0, \\ & U \geq 0, \quad V \geq 0. \end{aligned} \tag{4}$$

To evaluate DMU_o this model should be solved in turn for all units. It should be noted that this model may be infeasible for some units. At the end collecting the results the lower bound of efficiency will be resulted from the following formula:

$$\theta_o^{l*} = Min\{1, Min\{\theta_{oj}^l \mid j=1,\dots,n, j \neq o\}\}$$

Data

In this competitive world, considering a factor directly influenced the competition, has a major importance. Investigation and consideration of all accomplishment and failure factors, can result in alternatives which help in making decision. What has achieved a special importance for making decision is reliability and stability of a DMU under various circumstances (optimistic and pessimistic). Doubtlessly, taking a reliable action with an acceptable assurance interval is better than that with a high risk. What will be discussed here is ranking DMUs based on stability from the optimistic and pessimistic viewpoints in efficiency evaluation. As a matter of fact it can be propounded that in assessing DMUs considering mere optimistic efficiency score is not a criterion for ranking and performance evaluation of units. Since, in the event that an entity has gain a high efficiency score with a high risk it will not certainly have priority to that of with relatively balancing efficiency score, suitable confidence interval and a low risk. Thus, for ranking entities both efficiency and stability should be considered. These circumstances

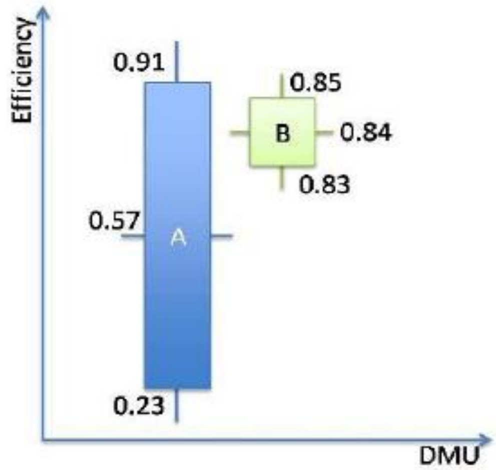

Figure 1. Efficiency interval.

Table 1. Inputs and outputs.

	O1	O2	O3	O4	O5	I1
Mean	0.2695	0.5904	0.9950	0.1158	0.2614	31.83847
Variance	0.0844	0.1851	0.0002	0.0567	0.1059	38.11880

are schematically depicted in Figure 1.

As it can be seen unit A with optimistic efficiency score of 0.91 is better than unit B with optimistic efficiency score of 0.85. But unit B, while it is considered from pessimistic viewpoint, has the efficiency score of 0.83 which is much better than that of unit A which is 0.23. Thus, in regarding the provided ranking method, ranking with efficiency intervals, unit B has a better rank order than that of unit A.

The important issue needs to be mentioned here is that the in efficiency scores of any two different units are different from each other. As stated in DEA literature it is not possible, for two different in efficient units, to have the same efficiency score. If this happens, by considering more decimal numbers it can be seen that the efficiency scores are different. This issue is true while the assessment is considered from either optimistic or pessimistic points of view. The only case where the efficiency scores are equal is for efficient units, with the efficiency score of one. But while supper efficiency scores of two different units are considered, the corresponding values are different from each other.

Considering the obtained upper and lowe bounds for efficiency, ranking units based on average of these score may be satisfactory. It should be noted that it is possible that the averages of two differedt pairs of numbers be the same. But the acquired efficicncy scores are real numbers and the case where the averages of two differedt pairs of real numbers be the same is very rare. This procedure is performed for ranking 1816 bank branches. Hence, through these branches, 100 units have been randomly selected. In this application one input and five outputs have been considered as listed in the following tables (Tables 1-3). In these tables mean, variance, ranges and related frequencies are listed.

RESULTS

As discussed, for ranking DMUs both optimistic and pessimistic viewpoints should be considered. The important issue is the stability of that unit with high average efficiency score which results in a better rank for the unit under assessment. In doing so, both efficiency scores, optimistic and pessimistic, are calculated and listed in Table 4.

As existing in literature, one of the famous ranking methods is supper efficicny which is provided by Anderson and Peterson (1993). Due to the existence of units with the upper and lower bound of efficiencies which are equal to 1, the supper efficiency in both pessimistic and optimistic viewpoints has been calculated.

As you can see unit 40 has the upper supper efficiency score of 1.325 and the correspondence lower supper

Table 2. Data description.

O1		O2		O3	
Range	**Frequency**	**Range**	**Frequency**	**Range**	**Frequency**
0.008-0.132	42	0.046-0.165	34	0.86-0.878	1
0.132-0.256	27	0.165-0.184	1	0.878-0.896	1
0.256-0.38	10	0.184-0.303	8	0.896-0.914	2
0.38-0.504	6	0.303-0.422	4	0.914-0.932	3
0.504-0.628	2	0.422-0.541	1	0.932-0.950	23
0.628-0.752	1	0.541-0.66	52	0.950-0.968	60
0.752-0.876	3	0.66-0.779	42	0.986-0.986	5
0.872-1	9	0.779-1	52	0.986-1	5

Table 3. Data description.

O4		O5		I1	
Range	**Frequency**	**Range**	**Frequency**	**Range**	**Frequency**
0-0.125	71	0.0005-0.13	56	19.58-22.54	2
0.125-0.25	8	0.13-0.255	17	22.54-25.5	17
0.25-0.375	1	0.255-0.38	2	25.5-28.46	21
0.375-0.5	3	0.38-0.405	1	28.46-31.42	8
0.5-0.625	1	0.405-0.53	7	31.42-34.38	10
0.625-0.75	1	0.53-0.655	2	34.38-37.34	14
0.75-0.875	5	0.655-0.78	1	37.34-40.3	22
0.875-1	10	0.78-1	14	40.3-43.29	6

Table 4. Ranks.

DMU	U.S.E	L.S.E	Mean	R1	R2	DMU	U.S.E	L.S.E	Mean	R1	R2
40	2.325	1.000	1.663	1	1	61	0.688	0.442	0.565	51	51
59	1.416	1.000	1.208	2	2	70	0.726	0.404	0.565	40	52
89	1.149	0.985	1.067	3	3	17	0.598	0.528	0.563	76	53
54	1.131	1.000	1.066	4	4	47	0.715	0.401	0.558	45	54
30	1.063	0.990	1.027	5	5	98	0.630	0.483	0.556	67	55
87	0.950	0.940	0.945	6	6	43	0.652	0.457	0.554	63	56
8	0.924	0.898	0.911	9	7	62	0.708	0.395	0.551	48	57
46	0.883	0.863	0.873	12	8	25	0.694	0.403	0.549	50	58
91	0.926	0.817	0.872	8	9	58	0.661	0.431	0.546	57	59
90	0.911	0.788	0.849	10	10	60	0.614	0.473	0.544	71	60
31	0.849	0.830	0.840	15	11	65	0.655	0.431	0.543	60	61
4	0.911	0.732	0.821	11	12	33	0.612	0.455	0.533	72	62
93	0.818	0.787	0.802	20	13	20	0.654	0.412	0.533	61	63
77	0.933	0.659	0.796	7	14	52	0.665	0.401	0.533	56	64
34	0.826	0.705	0.765	18	15	53	0.641	0.402	0.522	65	65
13	0.765	0.728	0.746	29	16	56	0.595	0.448	0.521	78	66
92	0.833	0.655	0.744	17	17	57	0.683	0.355	0.519	53	67
38	0.752	0.731	0.742	32	18	10	0.672	0.360	0.516	54	68
72	0.823	0.624	0.723	19	19	23	0.628	0.397	0.513	68	69

Table 4. cont'd

9	0.814	0.633	0.723	22	20	84	0.636	0.384	0.510	66	70
64	0.867	0.574	0.721	14	21	99	0.565	0.440	0.503	93	71
73	0.881	0.554	0.717	13	22	27	0.657	0.345	0.501	58	72
95	0.802	0.631	0.716	24	23	51	0.624	0.377	0.500	69	73
5	0.733	0.655	0.694	36	24	63	0.571	0.423	0.497	88	74
1	0.701	0.683	0.692	49	25	50	0.653	0.336	0.494	62	75
80	0.838	0.537	0.687	16	26	94	0.523	0.460	0.492	98	76
96	0.687	0.661	0.674	52	27	71	0.620	0.362	0.491	70	77
86	0.815	0.526	0.671	21	28	81	0.611	0.365	0.488	73	78
67	0.801	0.532	0.667	25	29	19	0.597	0.371	0.484	77	79
66	0.729	0.599	0.664	38	30	78	0.605	0.358	0.482	74	80
7	0.732	0.582	0.657	37	31	12	0.591	0.351	0.471	79	81
82	0.800	0.494	0.647	26	32	55	0.576	0.364	0.470	84	82
24	0.809	0.484	0.646	23	33	48	0.599	0.338	0.468	75	83
88	0.709	0.561	0.635	47	34	97	0.581	0.347	0.464	82	84
41	0.796	0.458	0.627	27	35	37	0.589	0.337	0.463	80	85
42	0.652	0.584	0.618	64	36	6	0.568	0.357	0.463	89	86
26	0.777	0.445	0.611	28	37	68	0.583	0.340	0.462	81	87
18	0.752	0.462	0.607	33	38	32	0.578	0.341	0.460	83	88
3	0.757	0.444	0.601	30	39	29	0.567	0.349	0.458	91	89
39	0.719	0.481	0.600	44	40	11	0.575	0.339	0.457	85	90
100	0.752	0.444	0.598	31	41	36	0.572	0.335	0.453	87	91
35	0.752	0.437	0.594	34	42	75	0.551	0.353	0.452	95	92
85	0.749	0.428	0.588	35	43	21	0.574	0.327	0.450	86	93
49	0.666	0.498	0.582	55	44	83	0.566	0.334	0.450	92	94
28	0.726	0.431	0.578	41	45	69	0.562	0.328	0.445	94	95
22	0.724	0.431	0.578	42	46	15	0.567	0.312	0.440	90	96
2	0.723	0.431	0.577	43	47	44	0.531	0.304	0.418	96	97
14	0.714	0.440	0.577	46	48	79	0.523	0.305	0.414	99	98
16	0.726	0.417	0.572	39	49	76	0.525	0.299	0.412	97	99
74	0.656	0.486	0.571	59	50	45	0.514	0.291	0.403	100	100

efficiency is 1. Certainly, this unit can be introduced as a pioneer. This is, the same circumstances for unit 59 and 54. But the major point is that unit 89 with the lower and upper bounds of 1.0149 and 0.985, respectively, has gained a better rank order in comparison to that of unit 54. It is worth mentioning that the reason is due to the priority in the optimistic case with the extent of 0.018 and the inferiority in the pessimistic case in the extent of 0.015. Thus it gains a better rank order. This issue is set up for units 46 and 91 in an other manner. Unit 46 has more stable and appropriate efficiencies, with the lower and upper bounds of 0.863 and 0.883 respectively, and these two for unit 91 is 0.817 and 0.926. It is evident that it has a more confidential performance relative to unit 91 thus it gains more reliability. Since in pessimistic viewpoint it has superiority with the extent of 0.046 to that of unit 91 and it has higher average efficiency.

Moreover, according to what has been provided in Table 4 a fundamental difference in unit 42 can be seen which is, this unit has improved its status 28 levels while considering conventional rank order; that means considering just the upper bounds. Also, unit 91 and 1 have improved their statuses, respectively, and they have witnessed 25 and 24 level raises; thus they have gained better ranks. Furthermore, units 27, 10 and 57 have witnessed 14 level drops in their corresponding ranks and these units are of the most unstable units. As you can see the upper and lower efficiency bounds correspond to unit 27 are, respectively, 0.657 and 0.343. It should be noted that in the case of pessimistic viewpoints the efficiency of this unit has been reduced to half. Thus, it gains the rank of 72th. It should be mentioned that in the conventional ranking method it has the rank order of 58.

In the Table 4 the results of ranking DMUs are gathered.

Under the column U.S.E and L.S.E, the upper supper efficiency and the lower efficiency are listed, respectively. Under the column named R1 DMUs are ranked according to the upper bound of efficiency and under the column R2 they are ranked according to the upper and lower bounds of efficiency.

In Table 4, there is a major rank difference between these two ranking methods. For instance, considering unit 40 there is no rank difference. But for unit 8, this deference is +2 which means the first rank, based on the upper bound, is better than that of the second one, which is based on the upper and lower efficiencies. Moreover, this difference for unit 91 is -1 which means the second rank, which is based on the upper and lower efficiencies, is better than that of the first one, based on the upper bound.

Conclusion

DMUs can be relatively evaluated from various viewpoints and as a result the efficiency scores are acquired as intervals. Considering a factor directly influenced the competition in this competitive world, has a fundamental significance. Thus, Investigation and consideration of all factors correspond to accomplishment and failure can lead to different alternatives which help making decision. This has achieved a special importance for making decision is reliability and stability of a DMU under various circumstances (optimistic and pessimistic). In this paper an approach has been proposed for ranking according to the efficiency intervals while optimistic and pessimistic efficiency scores are considered. Since, in the event that an entity has gained a high efficiency score with a great risk certainly it will not have priority to a unit with relatively balancing efficiency score, suitable confidence interval and a low risk. Thus, for ranking entities both efficiency and stability should be considered. The proposed ranking method in this paper does not suffer from ranking non extreme efficient units, as most of rankig methods do, and moreover it is always feasible. Besides, through finding lower efficiency it can be found that to what extent a unit can risk. In this method the case where a unit operates badly can also be distinguished. In this case corresponding lower efficiency will decrease a lot. Also, if the lower bound of efficiency is acceptable this means that the under assessment unit, in most of the situations, performs well. One more issue that needs to be mentioned is that in this method the other units do not affect the rank order of the under evaluation unit, as in supper efficicny method in which the new efficicnt frontier constructed throuh the remaining units and the under evaluation unit has been compared to this frontier. Moreover, the proposed ranking method is merely affected from the corresponding efficiency bounds.

Conflict of interest

Author(s) have not declared any conflit of interest

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