Designing a knowledge-based system for strategic planning: A balanced scorecard perspective

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Abstract

First developed by Kaplan and Norton [Kaplan R. S., & Norton D. P. (1992). The balance scorecard – measures that drive performance. *Harvard Business Review*, 70(1), 71–79], balanced scorecard (BSC) provides an integrated view of overall organizational performance and strategic objectives. BSC integrates financial measures with other key performance indicators to create a perspective that incorporates both financial and non-financial aspects. BSC has proven a powerful tool for strategic planning and communicating strategy that assists in strategy implementation. Successful strategy implementation is based on effective strategic planning. Owing to the strategic planning being a virtual necessity in business, this work proposes an integrated approach for the balanced scorecard tool and knowledge-based system using the analytic hierarchy process (AHP) method, and then develops an intellectual BSC knowledge-based system for strategic planning that sets or selects firm management or operational strategies based on the following perspectives: learning and growth, internal/business process, customer, and financial performance. This system can help determine specific strategy weights. The intellectual BSC knowledge-based system facilities efficient automated strategic planning.
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1. Introduction

Academicians and researchers involved in strategic management and managerial accounting have devoted increasing attention in the recent decade to the influence of balanced scorecard (BSC) on organizational performance and strategic planning. The BSC designed by Kaplan and Norton (1992) uses a sequence of four perspectives that reflects firm value creation activities. The sequence is as follows: learning and growth perspective, internal/business process perspective, customer perspective, and finally financial perspective. Core outcome (performance) measures within each perspective are adopted as leading indicators of the core outcome measures in the next perspective. Since, its initial development by Kaplan and Norton, BSC

has been widely adopted by manufacturing and service companies, nonprofit organizations, government entities, and other industries around the world. Firms are increasingly implementing new performance measurement systems to track non-financial metrics, with related research including Andrews (1996), Banker, Chang, and Pizzini (2004), Banker, Potter, and Srinivasan (2000), Frigo (2002), Said, HassabElnaby, and Wier (2003).

Since its introduction in the early 1990s, the BSC has evolved from a performance measurement tool to a strategic management tool. The BSC methodology creates an infrastructure for strategic management activities. The scorecard introduces four new management processes that, separately and in combination, contribute to linking long-term strategic objectives and short-term actions (Kaplan & Norton, 1996a). By combining the financial, customer, internal process, and learning/growth perspectives, BSC helps managers understand numerous interrelationships and causal effects.

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This understanding can help managers transcend traditional notions regarding functional barriers and ultimately improve decision-making and problem solving. Strategy and execution reviews can help management teams review the strategic plans, the planning process, including BSC metrics and strategy maps (Frigo, 2002, 2004).

Strategic planning is virtually essential in business. A strategic plan differs from an operational plan. A strategic plan should be conceptual, visionary and directional. Owing to the complexity and importance of strategic planning, the knowledge-based system (KBS) is frequently used to support decision-making. Knowledge-based systems (KBS) are computer-based tools that facilitate managerial decision-making by presenting various effective alternatives. By the 1990s, intelligent knowledge-based systems came to play an important role in new decision support tools. But few studies involving KBS with BSC strategic management or planning have been done (Berler, Pavlopoulos, & Koutsouris, 2005; Martinsons, Davison, & Tse, 1999; Sohn, You, Lee, & Lee, 2003; Sundararajan, Srinivasan, Staehle, & Zimmers, 1998). This study thus provided an intelligent knowledge-based system for strategic planning that sets or selects firm strategy based on the BSC perspectives. This KBS can be used as a strategic planning tool planning or setting strategy based decision-making information. KBS is designed to offer a conclusive reference for helping decision makers make correct decisions in the face of complex situations and large quantities of information. Intelligent BSC knowledge-based system (BSCKBS) is designed to develop a strategic planning system for implementing business systems to support needs. Consequently, KBS adopts a user-oriented interface, and establishes management strategies based on assessment of the business vision and strategy.

Based on the above concern, this work has two related aims: (a) to propose an integrated framework for the balanced scorecard tool and knowledge-based system using the analytic hierarchy process (AHP) method; and (b) to develop an intellectual BSC knowledge-based system for strategic planning that sets or selects firm's strategy from the following perspectives: learning and growth, internal/business process, customer, and financial performance. Using the AHP method for the analysis, this work examines how management can select objectives and measures using the BSC hierarchy. This work addressed two key topics: setting objectives and the selection of appropriate measures. Firm executives are well aware that rapid implementation of change is difficult. However, strategic planning is important for strategy execution. Consequently, this work describes the use of AHP to prioritize all of the measures and strategies in a BSC framework and tries to establish an intelligent BSC strategic planning and management decision support system for strategic planning, that is, the BSC knowledge-based system (BSCKBS).

The remainder of this paper is organized as follows. Section 2 briefly reviews the knowledge-based system (KBS) and related applications. Section 3 briefly reviews the BSC view and related research. Section 4 then describes the AHP theorem and related research. Next, Section 5 describes the architecture of the BSC knowledge-based system and related content. Finally, concluding remarks and a summary are presented in Section 6.

2. Knowledge-based system and applications

2.1. The concept of knowledge-based system (KBS)

The computer user high-tech dictionary defines a knowledge-based system (KBS) as a computer system designed to imitate human problem solving via a combination of artificial intelligence and a database of subject specific knowledge. Knowledge-based systems are based on artificial intelligence (AI) methods and techniques. The core components of knowledge-based systems are knowledge-base and inference/reasoning mechanisms. KBS, like problem processing systems, function to retrieve information from a knowledge system and to use this information to obtain useful results and for decision-making. KBS are computer systems that represent knowledge in the form of heuristics for problem solving to assist humans in decision-making (Clark & Soliman, 1999). In practice, KBS is a frequent abbreviation for knowledge-based systems.

In the literature on KBS, Dhaliwal and Benbasat (1996) proposed that the four main components of KBS are generally as follows: knowledge-base, inference engine, knowledge engineering tool, and specific user interface. Chau and Albermani (2002) proposed that KBS comprise three basic components: knowledge-base, context and inference mechanism. The knowledge-base thus is the heart or core component of the KBS and contains domain expert knowledge stored via various representation techniques (such as semantic networks, frames and logic) (Curtis & Cobham, 2002); the most widely used technique or method is the "if (condition) then (action)" production rule.

2.2. The applications of knowledge-based system (KBS)

During the 1990s, academics and researchers began to recognize the importance of KBS and its related concepts became one of the most popular topics related to decision support tools or management information systems (MIS). Since its development KBS has been widely applied to various studies and issues, including performance assessment (Ammar, Duncombe, Jump, & Wright, 2004; Wang, 2005; Wang, Huang, & Lai, 2007), commercial loan underwriting (Kumra, Stein, & Assersohn, 2006), logistics strategy design (Chow, Choy, Lee, & Chan, 2005), farm productivity (Pomar & Pomar, 2005), mergers and acquisitions (Wen, Wang, & Wang, 2005a, 2005b), defense budget planning (Wen et al., 2005a, 2005b), earthquake design (Berrais, 2005), system dynamics (Yim, Kim, Kim, & Kwahk, 2004), conveyor equipment selection (Fonseca, Uppal, & Greene, 2004), customer service management (Cheung, Lee, Wang, Chu, & To, 2003) and knowledge inertia (Liao, 2002).

For example, Wang et al. (2007) proposed an assessment framework (namely, DSSPE) for evaluating state-owned enterprises (SOEs) using DEA models, including a database management subsystem, a model base subsystem, a knowledge acquisition subsystem, and a dialogue subsystem. Kumra et al. (2006) described an expert system-based approach (named MRA) for crediting underwriting that has been used commercially for over 10 years in various financial institutions. Chow et al. (2005) proposed the knowledge-based system (KLSS), which has been demonstrated to be suitable for application in the Hong Kong/ Pearl River Delta region, which enhances the effectiveness of logistics strategy formulation by integrating techniques such as data warehousing, on-line analytical processing, multi-dimensional database management and case-based reasoning. Moreover, Pomar and Pomar (2005) designed a knowledge-based decision support system (named CULL-SOW) for early identification of sows with low prolificacy in commercial pig farms. Finally, Berrais (2005) proposed a knowledge-based expert system (KBES) for earthquake resistant design of reinforced concrete buildings.

Consequently, the KBS has gained considerable acceptance recently in the current information management literature.

3. Balanced scorecard

3.1. Balanced scorecard (BSC) perspective

First devised by Kaplan and Norton (1992), the balanced scorecard approach comprises four perspectives: learning and growth perspective, internal process perspective, customer perspective, and financial perspective (Kaplan & Norton, 1993, 1996a, 1996b, 1996c, 2001a, 2001b, 2001c, 2001d, 2004a, 2004b, 2004c, 2004d, 2006). BSC is a strategic approach and performance management system which organizations can use for vision and strategy implementation. The BSC model comprises four new management processes that, separately and in combination, help link long-term strategic objectives with short-term actions (Kaplan & Norton, 1996a). Numerous companies and industries have adopted BSC, which meets several management needs. The BSC model is more than a collection of financial and non-financial measurements, and represents a translation of business unit strategy into a linked set of measures that define both long-term strategic objectives and the mechanisms for achieving and obtaining feedback regarding those objectives (Kaplan & Norton, 1996a). Furthermore, Kaplan and Norton (2004a) created a powerful new tool, *strategy map*, which companies can use to describe the links between intangible assets and value creation with an unprecedented degree of clarity and precision. Strategy map can be used to link processes with desired outcomes; to evaluate, measure, and improve the processes most critical to success, and to target investments in human, informational, and organizational capital (Kaplan & Norton, 2004a, 2004b).

The BSC model identifies four related perspectives on activities that are likely to be critical to most organizations and to all levels within organizations: (a) investing in learning and growth capabilities, (b) improving internal process efficiencies, (c) providing customer value, and (d) increasing financial success (Kaplan & Norton, 1992, 1993, 1996a, 1996b, 1996c, 2001a, 2004b).

3.1.1. The learning and growth perspective

Kaplan and Norton (1992) based their BSC model on activities that develop the learning and growth perspective. This perspective captures the ability of employees, information systems, and organizational alignment to manage a business and adapt to change. Process success depends on skilled and motivated employees, as well as accurate and timely information.

3.1.2. The internal process perspective

A causal model of BSC assumes that employee capabilities drive internal process improvement. Kaplan and Norton divided firm generic value chain activities into four high level process areas: (1) innovation; (2) customer management; (3) operations; and (4) regulations and environment. Each of these areas can include both major processes and sub-processes. The organizational pie thus can be sliced in various ways (Beiman & Sun, 2003).

3.1.3. The customer perspective

The customer perspective also identifies the outcomes associated with delivering differentiated value propositions. These outcomes include market share in specific customer segments, account sharing with targeted customers, acquisition and retention of customers in targeted segments, and customer profitability. Some studies have identified a significant relationship between customer satisfaction and performance, including Banker et al. (2000), Heskett, Jones, Sasser, and Schlesinger (1994), Ittner and Larcker (1998).

3.1.4. The financial perspective

Financial performance measures indicate whether firm strategy, implementation, and execution contribute to bottom-line improvement. The financial perspective includes three measures important to shareholders. Return-on-capital and cash flow reflect short-term preference, while forecast reliability indicates the desire of the corporate parent to reduce historical uncertainty associated with unexpected performance variation. Finally, project profitability focuses on the project as the basic unit for planning and control, while sales backlog helps reduce performance uncertainty (Kaplan & Norton, 1993).

3.2. BSC and KBS

According to Kaplan and Norton (1992), the BSC model was originally defined and designed as a framework to facilitate the reflection of business strategy in strategic

performance measures, where the core outcome (performance) measures in each perspective are assumed to be leading indicators of the core outcome measures in the next perspective. During the past decade researchers interested in BSC have argued that the BSC model is an effective communication tool and helps in achieving strategic alignment and planning. The BSC model helps align individuals and processes with organizational strategy (Kaplan & Norton, 1996b, 2001b). BSC designers use a unique management process known as cascading to align performance measures with business strategy (Kaplan & Norton, 1996b).

The previous literature on BSC is reviewed below. Bernard and Neely (2003) proposed that organization wide implementation of BSC requires IT support. Only a few studies have examined KBS or DSS with BSC, including Berler et al. (2005), Martinsons et al. (1999), Sohn et al. (2003), Sundararajan et al. (1998). For example, Berler et al. (2005) proposed an information model for knowledge management (KM) based on the use of key performance indicators (KPIs) in health-care systems. Additionally, Sohn et al. (2003) studied the relationship among corporate strategies, environmental forces, and BSC performance measures using AHP. Based on their empirical evidence, a decision support system is proposed to help retrieve the BSC weights of firms with similar characteristics. Martinsons et al. (1999) designed a balanced scorecard for information system (IS) that measures and evaluates IS activities from the following perspectives: business value, user orientation, internal process, and future readiness. Moreover, Sundararajan et al. (1998) discussed the application of a decision support system (DSS) for operational decision-making in a food processing industry.

The above demonstrates that BSC has emerged as a significant decision support tool in strategic management.

4. Analytic hierarchy process

4.1. Analytic hierarchy process (AHP) method

Designed to reflect actual human thinking, the analytic hierarchy process (AHP) was developed in the early 1970s in response to the scare resource allocation and planning needs of the military (Saaty, 1980, 1994). AHP is a powerful and flexible decision making process for helping people set priorities and make the best decisions in situations where it is necessary to consider both the qualitative and quantitative aspects of a decision. By reducing complex decisions to a series of one-on-one comparisons, then synthesizing the results, AHP not only helps decision makers make the best decision, but also provides a clear rationale for why that decision is the best. AHP is a hierarchical means of system representation. AHP involves decision makers in structuring a decision into smaller parts, proceeding from the goal, to objectives, sub-objectives, and finally alternative courses of action. Decision makers then make simple pair-wise comparison judgments throughout the hierarchy to prioritize the alternatives. The decision

problem can involve social, political, technical, and economic factors. AHP helps individuals cope with the intuitive, rational and irrational, as well as with risk and uncertainty in complex settings. AHP can be used to: forecast outcomes, plan projected and desired futures, facilitate group decision making, exercise control over changes in the decision making system, allocate resources, select alternatives, perform cost/benefit comparisons, assess employees and determine wage increases.

AHP is a comprehensive, logical and structural framework which can improve understanding of complex decisions by decomposing the problems involved in hierarchical structures. The incorporation of all relevant decision criteria and their pair-wise comparison allows decision makers to determine trade-offs among objectives. The application of AHP explicitly recognizes and incorporates the knowledge and expertise of those involved in priority setting, by using their subjective judgments, when the information base is poor. However AHP also integrates objectively measured information (such as, yields) provided such information is available.

AHP application is based on the following four principles (Saaty, 1994):

(1) *Decomposition*: A complex decision problem is divided into a hierarchy in which each level comprises a few manageable elements, after which it is further decomposed, and so on.
(2) *Prioritization*: Involves pairwise comparisons of various elements residing at the same level with respect to an element from the upper level of the hierarchy.
(3) *Synthesis*: The priorities are classified via the principle of hierarchic composition for overall assessment of available alternatives.
(4) *Sensitivity analysis*: Outcome stability is determined by testing the best choice against "what-if" type of changes in the criteria priorities.

4.2. AHP and BSC

Owing to its ability to assist organizations or firms in selecting among alternative missions or visions, selecting among alternative strategies, and allocating resources to implement organizational strategies and objectives, AHP has been successfully applied in BSC studies, including Fletcher and Smith (2004), Leung, Lam, and Cao (2006), Liberatore and Miller (1998), Reisinger, Cravens, and Tell (2003), Stewart and Mohammed (2001).

Leung et al. (2006) applied AHP and the analytic network process (ANP) to facilitate the implementation of BSC. Fletcher and Smith (2004) linked the EVA system to BSC, using the AHP methodology, to design a comprehensive measurement system for assessing overall organizational performance. Reisinger et al. (2003) proposed AHP as a mechanism for prioritizing organizational measures of BSC. Liberatore and Miller (1998) introduced an

approach (namely, AHP) for linking key performance measures of BSC directly to overall firm goals or objectives.

4.3. AHP and KBS

The literature on AHP includes various studies using KBS or DSS and AHP, including Aguaron, Escobar, and Moreno-Jimenez (2003), Forgionne, Kohli, and Jennings (2002), Luong (1998), Phillips-Wren, Hahn, and Forgionne (2004), Song and Lee (2002), Sundarraj (2004). Sundarraj (2004) described how a web-based system can standardize the management and support of service contracts using the AHP approach. Moreover, Phillips-Wren et al. (2004) proposed a framework for evaluating DSSs that combines outcome- and process-oriented evaluation measures. Meanwhile, Aguaron et al. (2003) focused on the evaluation of the consistency of human judgments in decision support systems (DSS) using the AHP approach. Forgionne et al. (2002) utilized the analytical hierarchy process to evaluate 20 leading decision-making support system journals and devised the journal rating DSS to assist evaluators in identifying high-quality DMSS journals. Furthermore, Song and Lee (2002) proposed a dynamic reasoning strategy that can consider dynamic decision-making behavior using a knowledge-based system-based on fuzzy rules. Finally, Luong (1998) developed a quantitative/qualitative decision support system for evaluating CIM which considers firm objectives and operating characteristics, thus ensuring that the selected technology matches individual firm needs.

5. The architecture of the BSC knowledge-based system

5.1. The architecture of BSCKBS

Inspired by previous studies, the main objective of this work is to fill a gap in the research by combining the BSC, KBS and AHP techniques to produce an improved approach to strategic planning and decision-making. KBS is a computer application that analyzes business data and presents this data to help facilitate user decision-making. Typical information that may be gathered and presented by a decision support application includes: (1) Non-financial measurements and financial performance. (2) Comparative financial information and data. (3) The consequences of different decision alternatives given previous experience with a specific context. A KBS may present information graphically and may include either an expert system or artificial intelligence (AI). A KBS may be focused on business executives or some other group of knowledge workers.

KBS are a specific class of computerized information system that supports business and organizational decision-making. A properly designed KBS is an interactive software-based system designed to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models for problem solving and decision-making. Consequently, this study applied a prototype KBS which linked the database management, model base, knowledge acquisition, and dialogue subsystems to construct a BSC knowledge-based system for strategic planning (BSCKBS).

The BSCKBS comprises four main components, as illustrated in Fig. 1, including: the database management subsystem, model base subsystem, knowledge acquisition subsystem, and dialogue subsystem. The database management subsystem primarily comprises a relational database managed by a software program known as the database management system, and which provides rapid data retrieval, updating, and appending. The BSCKBS database includes current or historical data, financial or non-financial information, and expert questionnaires from multiple applications or units. The model base subsystem includes the AHP model that enables the system to determine specific strategy weights. Modeling languages for building adequate models are also included and together are known as the model base management system. This work focuses on using the AHP model to assess decision weights. Meanwhile, the knowledge-based acquisition subsystem can support any of the other subsystems or act independently. The knowledge-based acquisition subsystem suggests alternatives or actions to decision makers. Additionally, the knowledge-based acquisition subsystem can be linked to the firm knowledge-base. Finally, the dialogue subsystem supports a friendly environment for communicating with and commanding the KBS via this subsystem.

The next section examines in detail each component of the BSC knowledge-based system (BSCKBS) and illustrates practical operations.
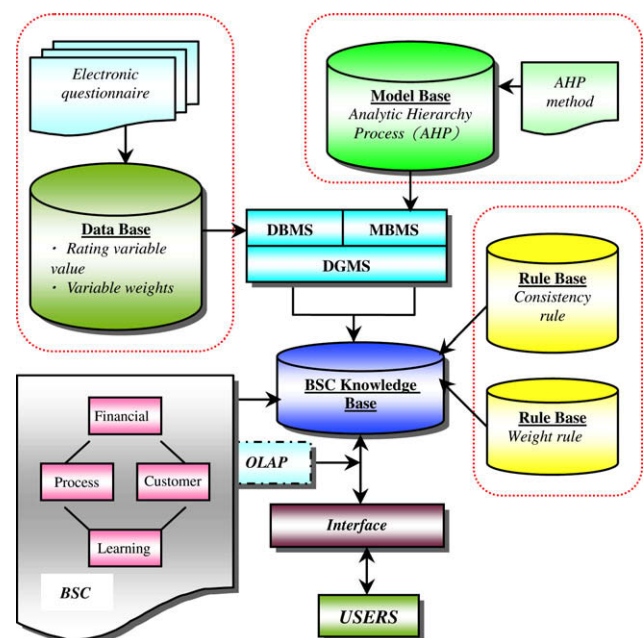

Fig. 1. The architecture of the BSC knowledge-based system (BSCKBS).

5.2. Database

A database is a shared, integrated computer structure that houses a set of end user data that comprises raw facts of interest to the end user, namely data about data. A database management system (DBMS) is required to manage data, answer ad hoc queries, improve access, and significantly reduce data inconsistency. DBMS is a collection of programs that manages a database structure and controls access to the data it contains. The DBMS described here uses Microsoft Access to create a database and an ODBC driver to connect the data in the database. The database described here primarily comprises expert questionnaires. Expert questionnaires were electronic instruments used to collect data from all participants. Data were collected as shown in Fig. 2. First, the system identified the list of participants. Next, variable values were obtained from the BSC perspective, which included the learning and growth, internal process, customer and financial perspectives. The database contained relevant scheduling information in the BSC knowledge-based system (BSCKBS), including pair-wise comparison matrix. The establishment of a pair-wise comparison matrix is designed to determine the relative importance among different elements. A nominal scale is used with values from 1 to 9 to measure the different weights (see Table 1). The system inputs the pair-wise comparison value of the criteria and strategies into the database with the web-based BSC knowledge-based system.

5.3. Model base

Mathematical models are good for application to well-structured decision problems that led to optimization solutions, while rule-based knowledge systems are good at dealing with unstructured and semi-structured problems where heuristic algorithms are used to obtain feasible solutions (Tian, Ma, & Liu, 2002). This study uses a model base on the decision support system to develop the AHP model for BSC strategic planning and management.

AHP is a hierarchical representation of a system. To illustrate the functions of AHP, the method is detailed below:

Step 1: Decision problem: weighting selection criteria.
Step 2: Framework for personnel selection.
Step 3: Establishing the decision hierarchy.
　　　　The step structures decision problems in a hierarchy, as shown in Fig. 3. BSCKBS employs a three-level hierarchy to link the strategies of the BSC to organizational goals. Ranking in decreasing order of importance, the three levels are: (1) organizational goal; (2) the four components of BSC; and (3) organizational strategies.
Step 4: Data collection from the selection panel.
Step 5: Employing pair-wise comparisons.
　　　　This step involves comparing the alternatives and criteria. Pairwise comparisons are performed for each element of the next higher level. This comparison is performed using the scale used in Table 1. This scale expresses comparisons verbally, and these verbal comparisons are then represented numerically.
　　　　AHP constructs a set of pair-wise comparisons in the form of a square matrix A, as follows:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & & \\ \vdots & & \ddots & \\ a_{n1} & & & a_{nn} \end{bmatrix}$$
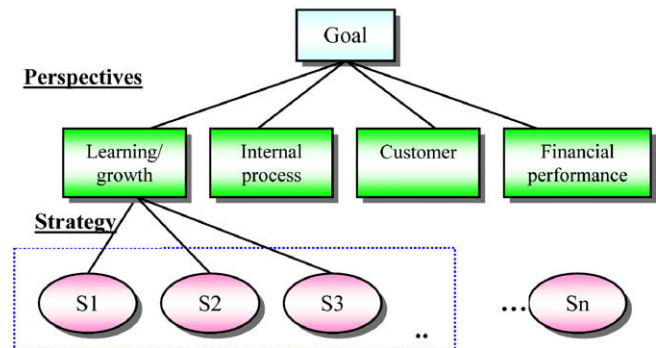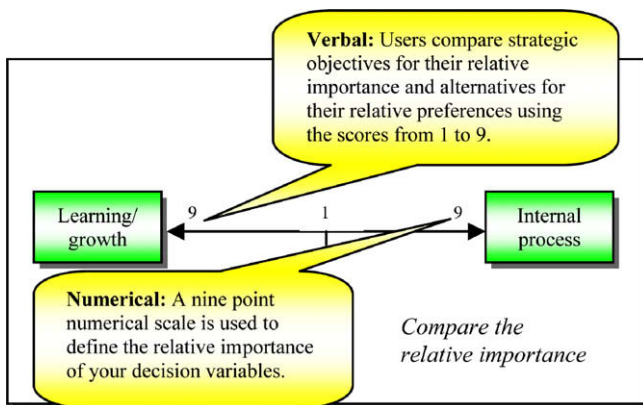

Fig. 2. Data collection.

Table 1
Fundamental scale for pair-wise comparisons

Verbal scale	Numerical values
Equally important, likely or preferred	1
Moderately more important, likely or preferred	3
Strongly more important, likely or preferred	5
Very strongly more important, likely or preferred	7
Extremely more important, likely or preferred	9
Intermediate values to reflect compromise	2, 4, 6, 8

Fig. 3. The basic structure of the hierarchy for the BSC.

where a_{ij} is a relative value with respect to factor j of i, $a_{ij} = 1/a_{ji}$ and $a_{ii} = 1$.

Step 6: Estimating relative element weights for each hierarchical level.

Step 7: Calculating the degree of consistency (CI) and consistency ratio (CR) to validate the results.

Saaty suggests a simple procedure for consistency checking, then the AHP process is applied to determine the consistency ratio (CR) for ah matrices. If the CR value exceeds 0.10 which is the acceptable upper limit for CR, it implies a 10% probability that the elements have not been properly compared. The decision maker must then review the comparisons.

If the pair-wise comparison matrix is consistent, the maximum eigenvalue (λ) should equal its number of order (n). The difference between these two values can be used to assess the consistency. In order references, the further calculation of the consistency ratio is also used to judge the degree of consistency. If the consistency index (CI) $\leqslant 0.1$, the consistency level is satisfactory. The assessment can be revised if any inconsistency is identified.

A consistency ratio (CR) is calculated to determine reasonable consistency. The consistency ratio (CR) is calculated as follows:

$$\text{Consistency ratio (CR)} = \text{CI}/\text{RI}$$

where CI = Consistency index = $(\lambda - n)/(n - 1)$; λ = average consistency measure for all alternatives; n = number of alternatives; and RI = appropriate random index.

Step 8: Calculating the relative weights of the ratings with an acceptable degree of consistency for the selection criteria.

5.4. Rule-based reasoning

Knowledge presentation is important in knowledge reasoning. A well-designed knowledge presentation will influence information system performance. Rule-based reasoning requires a well-constructed domain principle as its knowledge basis (Liao, 2001; Xu, 1996). Rule-based systems (RBS) use a procedural representation schema based on if-then rules to describe domain knowledge (delaOssa, Flores, Gámez, Mateo, & Puerta, 2007; Lau, Choy, Lau, Tsui, & Choy, 2004; Sedbrook, 2001; Wang, 2005; Wang et al., 2007). Rules take the form "if (condition) then (action)". Although Rule-based systems (RBS) always comprise rules with the form "*if antecedent then consequent*", they differ markedly (both syntactically and semantically) depending on the theory considered (such as multiple criteria decision-making logic). In this work, the BSCKBS focuses on multiple criteria decision-making logic; that is, the AHP rule-based on the use of two different types of rule-based systems: consistency rule and weight rule.

Table 2
Different types of decision-making rules

Different categories of rule	Production rule
Consistency rule: The rule is used for consistency level of expert questionnaires	*Rule 1:* If Conditional = "CR $\geqslant 0.1$"then reject
Weight rule: These rules are used for ranking of strategies.	*Rule 2:* If CR < 0.1 and Final_weight $\geqslant 10\%$, then Ranking = "1"
	Rule 3: If CR $< 0.1$and $5\% \leqslant$ Final_weight $<10\%$, then Ranking = "2"
	Rule 4: If CR $< 0.1$and Final_weight $< 5\%$, then Ranking = "3"

To clarify the forward chaining procedure, Table 2 lists several example rules used in the BSC knowledge-based system (BSCKBS) for strategic planning.

5.5. The implementation process for planning organizational strategies

Strategic planning is important for strategy execution. This work proposes an integrated approach for the balanced scorecard tool and knowledge-based system using AHP and then develops an intellectual BSCKBS for strategic planning that sets or selects firm management or operational strategies using the BSC perspective. Intellectual BSCKBS can rapidly implement automated strategic planning.

To implement BSCKBS, the first stage involves a team interview to confirm the performance perspective and management strategy via Delphi, with a consensus then being developed based on team opinion. Subsequently, AHP is performed based on team opinions and judgments to
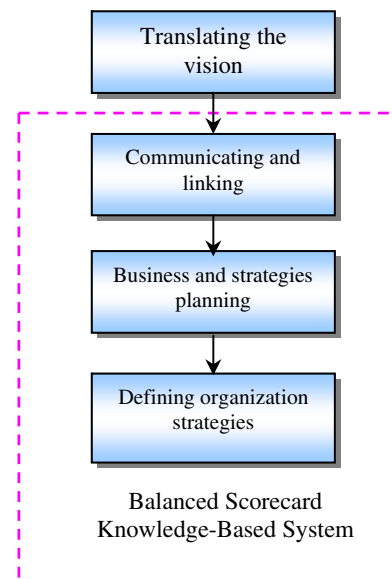

Fig. 4. The process for defining organization strategies.

obtain the management strategy weights. The system process in this work is shown in Fig. 4.

Step 1: *Translating the vision*

Management leaders assist project teams in key areas to monitor and understand dynamic and turbulent environment, and provide vision to their project teams and business. The project team members should clarify the organization vision; mission based on leader or strategy analysis and implements that vision in the organization.

Step 2: *Communicating and linking*

The web-based BSCKBS provides a discussion forum with a virtual meeting space. Project team members can use BSCKBS for strategy communication.

Step 3: *Business and strategy planning*

Teams generate highly effective and creative strategic opinions that respond to changes facing businesses. The team members attempt to formulate clear business strategies based on thorough analysis.

Step 4: *Defining organization strategies*

Following defining and clarifying organization mission and vision, the team members attempt to develop organization strategies using BSCKBS. The teams develop strategies based on sustainable competitive advantages.

6. Conclusions and future work

6.1. Conclusions

This work focused on the question of how management can select objectives and measures using the balanced scorecard hierarchy. This work applied KBS to examine this question, namely the BSC knowledge-based system (BSCKBS). Consequently, this work describes the design of a BSCKBS for strategic planning and management. The potential contribution of this work is as follows: first, this work provides a logical and reliable means for individual business units to describe and implement their strategic planning. This work used a nonparametric AHP method to analyze the organizational strategies and their relative weights. Thus, this work proposes using the analytic hierarchy process to prioritize all of the measures and strategies in a BSC knowledge-based system. Second, this system can help determine the weights of specific strategies. The intelligent BSCKBS can help clients to more effectively execute strategic plans for improved business results. Furthermore, the intelligent BSCKBS is suitable for substantial start-ups, established businesses and strategic business units.

6.2. Implications and future research

The work concludes discussing theoretical, research and practical implications. This study has several practical implications. BSC has been demonstrated to be a powerful tool for setting objectives and appropriate measures to facilitate objective achievement. Management thus makes an effort to learn how to practically apply the integrated BSCKBS to achieve organizational competitive advantages and effective strategic planning. This work concludes that firm or organization administrators can use this analysis to help identify and manage strategic indicators and linkages when adopting BSCKBS.

Several recommendations regarding future work and research can help explore BSCKBS, including not only the concept of the architecture of BSCKBS, but also its practical usefulness.

First, BSCKBS is web-based, and uses Windows to access the Internet. This system is designed using HTML and ASP, and managed by Access database.

Second, recently, rule-based reasoning (RBR), case-based reasoning (CBR) and model based reasoning (MBR) have emerged as important and complementary reasoning methodologies for application to intelligent systems. For complex problem solving, it is useful to integrate RBR, CBR and MBR in decision-making. In the future, BSCKBS should integrate RBR, CBR and MBR for strategic planning and strategy implementation.

Finally, it is recommended that the approach outlined in this work be replicated in other industries and firms. Future studies should focus on validating the proposed BSCKBS and associated strategic objectives and performance measures, and on implementing BSCKBS to the other companies or organization to test its effectiveness for strategic planning.

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