Technological Forecasting & Social Change 78 (2011) 1254–1267

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

A grey decision and prediction model for investment in the core competitiveness of product development

Yuan-Yeuan Tai [a], Jenn-Yang Lin [b,1], Ming-Shi Chen [c], Ming-Chyuan Lin [a,*]

[a] Department of Industrial Design, College of Planning and Design, National Cheng Kung University, Tainan 701, Taiwan
[b] Department of Creative Product Design, College of Arts, Nanhua University, Chiayi 622, Taiwan
[c] Department of Electronic Commerce, Transworld University, Douliou 640, Taiwan

ARTICLE INFO

Article history:
Received 18 December 2009
Received in revised form 25 December 2010
Accepted 1 March 2011
Available online 3 April 2011

Keywords:
AHP
Grey relation analysis
Product development
Decision analysis

ABSTRACT

Because enterprises do not disclose their internal specific cost information to the public and, moreover, every firm has its own product character and financial constitutions, it is difficult to offer fixed guidelines for investment decisions. Thus, an enterprise may be uncertain when required to choose the most promising set of possible investments.
The goal of this research is to use a grey relation analysis and analytic hierarchy process (AHP) to probe the core product development and competitiveness of an enterprise from limited data and, furthermore, by constructing the grey model, *GM*(1,1), to validate the feasibility of this assessment of the core competitiveness and investment strategy. In this study, a precision mechanical manufacturer is taken as an example, and the forecast estimate from this method is compared to those of a linear regression and the actual values to demonstrate the feasibility of applying this methodology to investment decision making, hence, demonstrating the value of this research.

1. Introduction

There are many factors to be considered in assessing an enterprise's profit trend and its future advancements, including cash flow, inventory management, marketing, supply chain management and analysis of competitors. Hamel [1] emphasized that an enterprise's strategy should be based on its core competitiveness and that the future primary interest of an enterprise should be focused on building its core competitiveness. Moreover, to probe the method of increasing enterprise competitiveness, an enterprise should use the components of core competitiveness, such as connotation, characteristics, categorization, market attributes and recognition ability. The core competitiveness of an enterprise is formed progressively during its long-term operation, and the management of core competitiveness plays an important role in an enterprise's competitive strategy, as it affects the entire enterprise's advantages and determines its long-term profits. However, there are cross-interactions between each of the factors, and it is difficult to assess or predict core competitiveness with a deterministic model. Research on the core competitiveness of an enterprise, its resources and value-added activities should be considered first: that is, to find the value added during product development and all the activities of the enterprise, to maximize possible competitive advantages and to develop increases in their value and competitiveness, and, ultimately, the core competitiveness of the enterprise as a whole. Thus, theoretically, it is necessary to develop a systematic procedure to help an enterprise identify its own core competitiveness, maximize its advantages, diversify development, facilitate strategy making and, finally, increase its competitiveness.

* Corresponding author. Tel.: +886 6 2757575x54327; fax: +886 6 2522609.
E-mail addresses: terrytai@ms.aidc.com.tw (Y.-Y. Tai), design@mail.nhu.edu.tw (J.-Y. Lin), mschen@twu.edu.tw (M.-S. Chen), minglin@mail.ncku.edu.tw (M.-C. Lin).
[1] Tel.: +886 5 2721001x2230; fax: +886 5 2427192.

0040-1625/$ – see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.techfore.2011.03.004

The analytic hierarchy process (AHP) is one theory of decision making based on an abstract hierarchical structure. When using the AHP approach, the decision maker can examine cross-correlations between factors within the structure and their impact on the whole system. The main applications of AHP are the following: planning, substitution planning, prioritization, resource distribution, needs assessment, results forecasting and risk evaluation, system design, performance evaluation, system stability assurance, and maximization and conflict settlement [2]. This analysis methodology has been proven effective and is widely applied to decision-making. Saaty [3] further proposed the concept of an analytic network process (ANP) that employs a super-matrix to record relative measurements within and between clusters of elements. Because the ANP approach can also incorporate dependence and feedback within a set of elements (inner dependence) and among different sets of elements (outer dependence), Saaty considered the AHP as a special case of the ANP [3]. However, this research will use the AHP approach in the evaluation structure based on the assumption that elements between layers and among elements of layers are independent of each other.

Currently, the fuzzy set theory of Zadeh [4] has been introduced to consider the complexity of uncertain or vague information on decision-making problems. The development of the fuzzy set theory is based on a fuzzy measure in which a graded value between 0 and 1 is assigned to each identified individual to indicate the degree of evidence or subjective certainty. Alternatively, in the grey theory, which originated with Deng in 1982 [5], the color "white" indicates that all the relevant information is completely known. Conversely, the color "black" means the relevant information is completely unknown. Between black and white, there is "grey," meaning the system information is partially known. The difference between the fuzzy set theory and grey theory is that the fuzzy set theory develops membership functions for the interval of fuzzy real numbers ranging from 0 to 1 and subjectively measures degrees of closeness for the specific attributes or alternatives, while the grey theory collects or specifies the range of values for the specific attributes or alternatives based the incomplete information and then initializes the values into grey real numbers with the base value of 1 [4,5]. Note that the measurement of fuzzy numbers requires sufficient expert knowledge. The measurement of grey numbers is based on the collection of existing data. The grey theory has been successfully used in a variety of fields, including grey control [6], process improvement [7], power requirement evaluation [8], product design [9,10], market requirement and market trend forecast [11], performance analysis [12], and quality improvement [13].

For the key performance evaluation, the relations between major factors are weighted to determine the performance index. Liang [14] proposed the grey relation analysis (GRA) in the problem solving of hydroelectric generation scheduling and demonstrated that the GRA approach can obtain a closer optimal schedule than other traditional approaches, such as differential dynamic programming (DDP) and self-organizing feature maps (SOFM). Feng and Wang [15] used the grey relation to rank the indicators in each performance evaluation category and select representative indicators to grade the airliners. Wang et al. [12] further applied the grey relation to the operation performance evaluation in assigning rankings and scores to airport performances. Because the grey relation approach is effective, it will be applied to evaluate and weight the index key factors that will be used to evaluate the enterprise performance.

In market demand forecasting, a variety of prediction models are available for specific problems. Conventional prediction models, such as multiple regression models, in statistical analysis are built to forecast the relationships between variables under certain ranges of observed data [16]. Saaty and Vargas [17] have introduced the AHP approach incorporating expert judgment in economic forecasts for the end effects of a given policy or set of policies and for determining the impact on important variables, such as unemployment and inflation. In the grey theory, a grey model, $GM(1,1)$, denoting a first-order differential equation with one variable, has also demonstrated accuracy in dynamic predictions and has been practically applied to several forecasting problems [8]. The $GM(1,1)$ model identifies a set of effective variables for a targeted system and forecasts the future values based on a time-series set of historical data [5]. The $GM(1,1)$ model has been compared to general linear regression and has proven to be more accurate for long-term load forecasting than general linear regression [8]. The $GM(1,1)$ model is further modified by residual series and has been used in predictions for the air passenger market with reliable results [18]. The model has also been applied to the market trends of the IC industry with higher quality short-term predictions than the time series of the exponential smoothing approach [19]. The historical annual power demands are used and an improved grey model is combined with residual modifications to predict the power demand. This method has been proven to yield more accurate results than the original $GM(1,1)$ model [20].

To apply the modified $GM(1,1)$ model to decision-making after the enterprise performance evaluation and market demand analysis, the relative relationship with the future biofuel consumption prediction model is developed by applying the grey relation analysis to various factors, including population, income, region, education, and occupation [21]. In developing market policy, by analyzing the requirements of the thin film transistor liquid crystal display (TFT-LCD) market, the related supporting industries and government policies, the short-term investment strategies are proposed using the $GM(1,1)$ model. The data are compiled from the database of the Taiwan Economic Journal Co. [22]. Note that the grey theory is also used in the strategic decision-making process to rank the material selection. Instead of traditional decision-making in material selection, which considers the function, cost, and manufacturability, the new approach evaluates the environmental impact and the life-cycle cost, including post treatment [23]. For the decision-making regarding the supplier selection in supply chain management, uncertain linguistic variables are expressed in grey numbers, and the ideal supplier is selected using the grey numbers to rank the selection order [24].

As mentioned above, using the grey correlation analysis and grey dynamic prediction models, more refined analyses and forecasts can be obtained for market demands and policy making. The relations between markets and policy can be analyzed using historical data of markets and can provide a good platform for product development. However, most previous studies focused merely on the demands and markets but overlook the competitiveness of the enterprise in the marketplace. Therefore, two points need to be further investigated: (1) if an internal competitiveness analysis of a company can be further considered in coordination with that aimed at the market demand and core competitiveness, it can help the company to select the most suitable product to maximize its profit; and (2) the financial evaluation of the enterprise's core competitiveness should be considered to improve the