Abstract. In recent years, many electronics producing firms have looked upon total quality management (TQM) strategy as a means by which they could maintain competitive advantage. This empirical research evaluates TQM strategic factors in order to determine the critical success factors in environmental uncertainty. Fuzzy analytic hierarchy process (FAHP) is the proposed research methodology to discuss and tackle the different decision criteria like effective leadership, people management, customer focus, strategic plan and process management, being involved in identifying the TQM strategic critical success factors with uncertainty. The result shows that effective leadership is the most critical success factor in TQM strategy.

Keywords: Total Quality Management, Fuzzy Analytical Hierarchy Process.

1. INTRODUCTION

The printed circuit board (PCB) industry in Taiwan plays a significant role in local electronic component manufacturing industries and in world market. The large volume production capability, quick response to demands, good quality products, on time deliveries and competitive pricing of Taiwan PCB manufacturers make them a viable supplier in the international market; industry output for PCBs totaled USD 48.7 billion, a strong performance which reflects the ability of the industry to handle rising prices of energy and raw materials. Thirty years of development and growth has made this industry rise to a manufacturing system from raw materials, equipment supply and manufacturing to end product assembly.

The PCB industry is expected to perform well in year 2006. However, competitiveness in the market appears to be a product of the adoption of a total quality management (TQM) strategy. Generally, TQM refers to a philosophy that aims to achieve customer satisfaction through strategic planning, effective leadership, people management, process management and customer focus in the organization (Samson and Terzirovski, 1999; Fuentes-Fuents, Albacete-Sae, and Llorens-Montes, 2004; Jung and Wang, 2006). Some recent studies suggest beneficial results from TQM implementation (Flynn, Salakibara and Schroeder, 1995; Forza and Filippini, 1998; Kaynak, 2003). Consequently, several approaches and models propose the introduction of TQM strategy (Dale, 1999; Prajogo and Sohal, 2006). However, the uncertainty and intensive competition in the issue of imperative factors of TQM criteria and attributes remains a challenge to the management.
The analytic hierarchy process (AHP) is widely used for tackling multi-criteria decision-making (MCDM) problems (Saaty, 1980). Despite its popularity and simplicity in concept, this method is often criticized for its inability to adequately handle the inherent uncertainty and imprecision associated in quantifying the decision-maker’s perception. In the traditional formulation of the AHP, human’s judgments are represented as exact numbers. Yet, in many practical cases the human preference model is uncertain and decision makers might be reluctant or unable to assign exact numerical values to the comparison judgments. Since some of the evaluation criteria are subjective and qualitative in nature, it is very difficult for the decision maker to express the preferences using exact numerical values and to provide exact pairwise comparison judgments. Therefore, it is more desirable for the researchers to use interval or fuzzy evaluations.

To improve the AHP method and to facilitate TQM criteria selection process, this paper introduces a fuzzy AHP (FAHP) approach using triangular fuzzy numbers to represent the comparison judgments of decision makers (Chang, 1996; Kang and Lee, 2006). The fuzzy set theory resembles human reasoning in its use of approximate information and uncertainty to generate decisions. It has the advantage of mathematically representing uncertainty and vagueness and providing formalized tools for dealing with the imprecision intrinsic to many problems. The proposed FAHP uses the triangular fuzzy numbers as a pairwise comparison scale for deriving the priorities of different TQM strategic criteria and attributes.

The priority weights of the each TQM strategic criteria are calculated and are based on the expert opinion from the PCB companies. In particular, the developed approach can adequately handle the inherent uncertainty and imprecision of the human decision making process and provide the flexibility and robustness needed for the decision maker to understand the decision priorities. These merits of the proposed method would facilitate its use in real-life situations for making effective decisions. This study attempts to identify the critical criteria and attributes in TQM strategy for PCB producing firms using FAHP. This study aims to build up and expound a hierarchical model to aid in the prioritization of TQM strategic criteria and attributes, and to identify the TQM strategic critical success factor as benchmark for all PCB producing firms.

2. RELATED LITERATURE

2.1 Fuzzy AHP

Researchers propose various FAHP methods, which are systematic approaches to alternatives selection and choice justification. Van Laarhoven and Pedrycz (1983) provide the earliest work on FAHP, comparing fuzzy ratios described by triangular membership functions. On the other hand, Buckley (1985) determines fuzzy priorities of comparison ratios with trapezoidal membership functions. The study of Stam et al. (1996) explores how recently developed artificial intelligence techniques can be used to determine or approximate the preference ratings in AHP and proves that the feed-forward neural network formulation appears to be a powerful tool for analyzing discrete alternative MCDM problems with imprecise or fuzzy ratio-scale preference judgments. Chang (1996) introduces a new approach for handling FAHP with the use of triangular fuzzy numbers for pairwise comparison scale and the use of the extent analysis method for the synthetic extent values of the pairwise comparisons. Weck, et al. (1997) presents a method to evaluate different production cycle alternatives, adding the mathematics of fuzzy logic to the classical AHP. Any production cycle evaluated in this manner yields a fuzzy set. The outcome of the analysis can finally be defuzzified by forming the surface center of gravity of any fuzzy set, and the investigated alternative production cycles can be ranked in order in terms of the main objective set.

Kahraman et al. (2003) uses fuzzy objective and subjective method to obtain the weights from AHP and make a fuzzy weighted evaluation. Deng (1999) presents a fuzzy approach for tackling qualitative multi-criteria analysis problems in a straightforward and simpler manner. Lee et al. (1999) reviews the basic ideas behind AHP. Based on these ideas, they introduced the concept of comparison interval and proposed a methodology based on stochastic optimization to achieve global consistency and highlight the fuzzy nature of the comparison process.

Cheng et al. (1999) proposes a new method for evaluating weapon systems through analytical hierarchy process based on linguistic variable weight. Zhu et al. (1999) provides a discussion on extent analysis method and applications of FAHP. Chan et al. (2000) presents a technology selection algorithm to quantify both tangible and intangible benefits in uncertainty. They describe an application of the theory of fuzzy sets to hierarchical structural analysis and economic evaluations. By aggregating the hierarchy, the preferential weight of each alternative technology is found, which is called fuzzy appropriate index. The fuzzy appropriate indices of different technologies are then ranked and preferential ranking orders of technologies are established. From the economic perspective, a fuzzy cash flow analysis is employed.

Cheng et al. (2005) implemented the FAHP method to help telecom carriers evaluate and plan future broadband Metropolitan Area Network access strategy. Kahraman et al. (2004) presents four different fuzzy multi-attribute group decision-making approaches including FAHP on a facility location selection problem. Bozdag et al. (2003) implemented FAHP to select best computer integrated manufacturing system by taking into account both intangible and tangible factors. Sheu (2004) presents a hybrid fuzzy-based method that integrates fuzzy AHP and fuzzy MCDM approaches for identifying global lo-