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To construct a monitoring mechanism of production loss by using Fuzzy Delphi method and fuzzy regression technique – A case study of IC package testing company

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Abstract

The development of information technology and internet capabilities over the years has been at an accelerated pace of global intense challenges and competitions of the technologies markets. Therefore, the issue of effectively utilizing valuable information located in databases worldwide, by monitoring the performance of their operations became an important issue in the electronic business environment. Methods to address this issue were employed to quickly identify the Key Performance Indicators (KPI's) and operational problems and clarify any relationships between them, to allow the overall business objectives to be achieved. In this paper, the Fuzzy Delphi and ranking methods were used to extract the most concerning issues through expert questionnaires. A fuzzy regression model was then constructed and applied to clarify the relationships between the KPI's and the key management objective, the area of production loss. Therefore, the key factors for future improvements were obtained by tracking the fuzzy regression model. Finally a case study of a semiconductor assembly and testing, through a company in Taiwan, was used to illustrate the proposed framework. The results indicated that this model could be easily implemented to analyze the influence of concerned KPIs on key management objectives.

Keywords: Fuzzy Delphi method; Fuzzy ranking; Key performance indicator; Fuzzy regression

1. Introduction

The development of information technology and internet over the years has been a series of challenge-intense global competitions as markets become keener than ever. Think global but decide local has become the basis for decision making in business management with expectations running high regarding the use of digital-information. This has had tremendous impact on business, requiring management to design performance management systems that monitor performance efficiently and provide data consolidation and integration, especially when the data was generated from diversity systems, e.g. Enterprise Resource Planning (ERP), Supply Chain Management (SCM), and Manufacturing Execution System (MES).

Our goal was to efficiently monitor business operations; provide useful managerial information; highlight undesired symptoms in business operation; then design KPIs (more useful than inspecting all Performance Indicators (PIs)). To complete the above tasks, we first focused on finding out important issues facing enterprise. This was done by the distribution of surveys to the top management level of different departments, to collect and correlate their observations to define the most concerning production problems. Secondly, we constructed the relationships between KPIs through the application of data mining techniques and a regression model was defined.

The remainder of this paper is organized as follows; Section 2 presents the related studies with regard to this research; Section 3 presents the proposed architecture for

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constructing a monitoring mechanism of production loss; Section 4 illustrates a case study of a semiconductor assembly and testing through a company in Taiwan; Section 5 offers the summary and conclusions of this paper.

2. Literature review

Performance measurement is a management system which enables organizations to operate effectively and efficiently. The Balanced Scorecard (BSC) developed by Kaplan and Norton (1996) can help an organization to evaluate performance and to reach long-term success. PIs can provide personnel performance appraisal standards, supply criteria for evaluation of human source development, identify valid interventions and define new organizational goals. All PIs should have some kind of linkages, i.e. there exists interactions between them (Kaufman, 1998). Basically, a PI is a transaction-based, pre-active measurement indicator. It differs from KPIs in that it offers a post-active metric that measures occurrences. KPIs provide us with a preventive viewpoint. However, designed KPIs can help top managers to measure the success of production management and to define a suitable set of PIs for monitoring ongoing performance. It can also help enterprises to design decision support systems, e.g. Business Intelligence System (BIS) Rakar, Zorzut, and Jovan (2004) for the purpose of effective management. Rakar et al. (2004) proposed a hierarchical structure for industrial management systems and an iterative closed-loop model to derive KPIs.

To the above purpose and efficient conclusion of useful information, one should focus on critical issues of enterprise. The traditional Delphi method, developed by Dalkey (1950), has been widely used to obtain a consistent flow of answers through the results of questionnaires (Hwang & Lin, 1987; Reza & Vassilis, 1988). Delphi is an expert opinion survey method with three features: anonymous response, iteration and controlled feedback and finally statistical group response. However some weaknesses have been exposed, it needs repetitive surveys to allow forecasting values to converge which requires much more time and cost (Hwang & Lin, 1987; Ishikawa et al., 1993). Furthermore, in many real situations, experts' judgments can not be properly reflected in quantitative terms. Some ambiguity will result due to the differences in the meanings and interpretations of the expert's opinions. Since people use linguistic terms, such as 'good' or 'very good' to reflect their preferences, the concept of combining fuzzy set theory and Delphi was proposed by Murray, Pipino, and Gigch (1985), and named the Fuzzy Delphi method. To improve the shortcomings of vagueness and ambiguousness of Delphi, group membership functions were used to compute the expected values of fuzzy numbers, then a forecasting value could be obtained (Huang, Chang, & Lin, 1997; Kaufmann & Gupta, 1988).

Chen and Hwang (1992) proposed eight conversion scales to convert a linguistic term into a fuzzy number. Fuzzy set theory was introduced by Zadeh (1965), and is different from traditional set theory, as it uses the concept of membership functions to deal with questions that cannot be solved by two-valued logic. A convex and normalized fuzzy set defined on a real number, whose membership function is piecewise continuous, is called a fuzzy number $\widetilde{M}$ (Dubois & Prade, 1980; Klir & Folger, 1988; Zimmermann, 1966). An α-level set of a fuzzy number $\widetilde{M}$ is a crisp set denoted by M_α whose membership values are greater than or equal to α (Zimmermann, 1966). After 1965, fuzzy set theory concepts were applied to solve special dynamic processes, especially those observations concerned with linguistic values. The most generally defined and widely used fuzzy number is $L-R$ fuzzy number (Dubois & Prade, 1980), and the membership function $\mu_{\widetilde{M}}(x)$ of a trapezoidal fuzzy number $\widetilde{M}=(a,b,c,d)$ is defined as (1) with linear functions L and R as shown in Fig. 1. Furthermore, when b and c are coincident, a triangular fuzzy number is defined as (2) and shown in Fig. 2.

$$\mu_{\widetilde{M}}(x)=\begin{cases}0 & x<a \text{ or } x>d\\ \frac{x-a}{b-d} & a<x<b\\ 1 & b\leqslant x\leqslant c\\ \frac{d-x}{d-c} & c<x<d,\end{cases} \tag{1}$$

$$\mu_{\widetilde{M}}(x)=\begin{cases}\frac{x-a}{b-a}, & a\leqslant x\leqslant b\\ \frac{c-x}{c-b}, & b<x\leqslant c\\ 0, & \text{otherwise.}\end{cases} \tag{2}$$

When survey questionnaires are performed, the important degree or frequency of main issues of each dimension can be obtained. The validity and reliability need to be tested, if any Cronbach's α is less than 0.35 (Guieford, 1965), the corresponding datum is not reliable and will be deleted. The membership functions of each issue can be constructed and the forecasting value used for comparison is derived, this is a process of defuzzification to rank fuzzy numbers. Ranking fuzzy numbers is an important issue in ordering linguistic magnitude. Since 1976, researches have tried to develop ranking methods in order to generate a totally ordered set of fuzzy numbers (Chen & Hwang, 1992). Lin (2002) summarized the taxonomy and defects of the existing ranking methods to show that none of them can provide a complete order of fuzzy numbers. Most of the existing methods failed when two triangular fuzzy numbers had the same mode and symmetric spread. For example, two fuzzy numbers $\widetilde{M}_1=(0.3,0.5,0.7),\widetilde{M}_2=(0.4,0.5,0.6)$, as

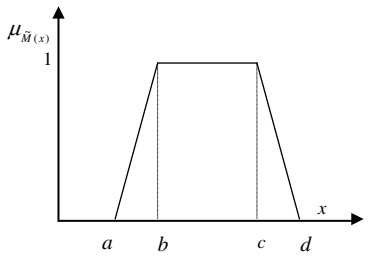

Fig. 1. The graph of a trapezoidal fuzzy number.