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Toward developing agility evaluation of mass customization systems using 2-tuple linguistic computing

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Abstract

Mass customization (MC) relates to the ability to provide individually designed products and services to every customer through high process flexibility and integration. For responding to the mass customization trend it is necessary to develop an agility-based manufacturing system to catch on the traits involved in MC. An MC manufacturing agility evaluation approach based on concepts of TOPSIS is proposed through analyzing the agility of organization management, product design, processing manufacture, partnership formation capability and integration of information system. The 2-tuple fuzzy linguistic computing manner to transform the heterogeneous information assessed by multiple experts into an identical decision domain is inherent in the proposed method. It is expected to aggregate experts' heterogeneous information, and offer sufficient and conclusive information for evaluating the agile manufacturing alternatives. And then a suitable agile system for implementing MC can be established.

Keywords: Mass customization; Agile manufacturing; Heterogeneity; TOPSIS; 2-Tuple fuzzy linguistic computing

1. Introduction

Due to the globalization of competition in the manufacturing industry and the diversification of customers' demands, more requirements for enterprises have been put forth at present, such as more product variety, shorter time-to-market, lower product cost and higher quality. The enterprises respond to fierce competition and increasing consumer awareness with shorter product life cycles, quicker delivery of new products to the market, and decrease in operating costs at the same time. With product development times only one-third of their competitors and needing only a fraction of the resources, time-based manufacturing were capable to deliver new products much quicker to the market. This enabled quick response to changing market preferences, and the continuous introduction of innovative technology. Time-based manufacturers were able to continually introduce new products with more features, increasing the variety offered to customers. From the success of time-based competition emerged a new paradigm-mass customization (MC) (Alford, Sackett, & Nelder, 2000).

MC as a viable approach to competitive strategy is capturing the imagination of both managers and business academics. The growing interest in MC has led researchers to suggest that firms that shift from mass production to the emerging paradigm of MC will gain a competitive advantage (Kotha, 1996; Silveira, Borenstein, & Fogliatto, 2001; Wang, 2007). The term mass customization was coined by Davis (1989) who predicted that the more a company was able to deliver customized goods on a mass basis, relative to their competition, the greater would be their competitive advantage. Pine II (1993) stated that mass customizers develop, produce, market and distribute goods and services with such variety that nearly everyone finds exactly what they want at a price they can afford. Manufacturers must look beyond the provision of standard products at low cost, to better meet the needs and desires of

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customers. With low cost, high quality and quick delivery simply qualifiers in the customer purchasing process, manufacturers must customize products or services to humor customer needs and stimulate market demand. Hart (1995) offered an operational definition that MC is the use of flexible processes and organizational structures to produce varied and often individually customized products and services at the price of standardized, mass produced alternatives. Consequently, MC as a competitive strategy requires that different production types be employed simultaneously. The concepts of flexibility, timeliness and variety are essential to the intention of mass customization. In recent years, the development efforts of MC have been mostly concentrated on agile manufacturing, but little has been focused on systematic perspective about the agility evaluation of manufacturing MC products.

Companies in either manufacturing or servicing have to be restructured or re-organized in order to overcome with challenges of the 21st century in which customers are not only satisfied but also delighted. To increase manufacturing responsiveness yet reduce costs incurred by frequent changeovers, many enterprises transform the factory into an agile manufacture facility. This agility copes with changes in customer requirements including price, quality, customization, and promised delivery dates. Agile manufacturing (AM), a relatively new operations concept that is intended to improve the competitiveness of firms, has been advocated as the 21st century manufacturing paradigm (Sanchez & Nagi, 2001). It is seen as the winning strategy to be adopted by manufacturers bracing themselves for dramatic performance enhancements to become national and international leaders in an increasingly competitive market of fast changing customer requirements. AM can be grouped under the following themes: (i) strategic planning, (ii) product design, (iii) virtual enterprise, and (iv) automation and information technology (Gunasekaran & Yusef, 2002). The goal of this paper makes a point of developing an evaluation approach for determining the most suitable agile manufacturing system for implementing MC strategies.

For achieving an appropriate strategy the business decision mechanism is usually composed of multiple experts who implement alternatives evaluation and decision analysis in the light of association rules and criteria. Experts devote to judge by their experiential cognition and subjective perception in decision-making process. However, there exist considerable extent of uncertainty, fuzziness and heterogeneity (Hwang & Yoon, 1981). Consequently, the heterogeneous information that includes crisp values, interval values and linguistic expression is likely to happen under different criterion. Effective aggregation for each kind of assessments generated by experts to implement substantial and correct decision – analysis is a critical managerial issue. Developing a heterogeneous information aggregation platform to evaluate and rank appropriate alternatives is an indispensable essential to a robust decision mechanism. Chen (2000) extended the TOPSIS to group decision making problems under fuzzy environment and applied a vertex method to calculate the distance between two triangular fuzzy numbers. According to the concept of the TOPSIS, a closeness coefficient is defined to determine the ranking order of all alternatives by calculating the distances to both the fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS) simultaneously.

Based on suchlike ideas this research therefore focuses on establishing an agility measurement approach for MC manufacturing system. We apply concepts of the TOPSIS manner which is based on values of the best and the worst fuzzy linguistic, and determines the alternative sequence of agile manufacturing systems on the strength of the distance computation of linguistic variables under fuzzy decision environments. The proposed method is to adequately come at connotation of every evaluated alternative and then to enhance the believability and the adoptability of analysis results, as well as to increase productivity for achieving the goal of MC.

The rest of this paper is organized as follows. Next Section discussed the dimensions of agility evaluation. Section 3 presented the basic definitions and notations of the fuzzy number and linguistic variable as well as three kinds of heterogeneous information transformation, respectively. In Section 4 we proposed a fuzzy linguistic agility evaluation model for the selection of MC systems. And then, the proposed method is illustrated with an example. Finally, some conclusions are pointed out in the end of this paper.

2. Dimensions of agility evaluation

To be agile in the global competitive environment, the enterprises conclude specific objectives for the production system to be more responsive to customer demands, be able to adjust schedules more frequently, anticipate and avoid production delays and detect quality problems before they became disruptive (Katayama & Bennett, 1999). Suchlike objectives generally include responsiveness, customization, competitive pricing, small lots, quick changeovers, minimum WIP, modern technology, skillful workers, efficient facilities, and so forth. The keys to conforming to these objectives are to thoroughly reduce the lot size and install an online, real-time communication system throughout the organization with special emphasis on the production floor. Agility and flexibility are consequently required to accommodate the dynamic workload imbalances inherent in generating distinct product styles.

To hold out agility in company's competitive environment, the production system must be proficient at responding to frequent adjustments to the schedule and hourly changeovers in the production lots. In accordance with the individual demands an agile manufacturing system is necessary to settle on for producing mass customization products. Consequently, the corresponding desirable agility evaluation method is worthy of development. Yang and Li (2002) concluded that the MC product processing manufacture agility evaluating index system established