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Fuzzy multiple goal programming applied to TFT-LCD supplier selection by downstream manufacturers

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ABSTRACT

In today's highly competitive environment, a good supply chain relationship is essential for a company to survive and to acquire reasonable profit. While a few large companies may be able to vertically integrate from the design stage to the final distribution of the entire supply chain, most companies can only focus on their specialized functions and to cooperate with upstream or downstream companies. Supplier selection, as a result, is very important for maintaining strategic alliances. The objective of this paper is to develop a fuzzy multiple goal programming (FMGP) model to help downstream companies to select thin film transistor liquid crystal display (TFT-LCD) suppliers for cooperation. Fuzzy analytic hierarchy process (FAHP) is applied first to analyze the importance of multiple factors by incorporating experts' opinion, and these factors include cost, yield and number of suppliers. Multi-choice goal programming is used next to consider the limits of various resources and to formulate the constraints. From the experimental design and examination, we can testify that the proposed model not only can consider multi-choice goals, decision-making behavior and limit of resources, it can also allocate the purchase among the selected supplier(s).

1. Introduction

The spread of flat panel displays is inescapable in the digital era and will become an important human machine interface in the future. Because of their low weight, slender profile, low power consumption, high resolution, high brightness and low radiance advantages, the use of flat panel displays has been expanding from portable appliances to notebook and desktop monitors and even to large screen digital televisions. The two most important trends in flat panel display technology is larger display size along with higher resolution, and TFT-LCD is able to gain the greatest attention from both suppliers and consumers.

Outsourcing has become an important business approach since a competitive advantage may be gained by the cooperation with suppliers to provide products/services more effectively and efficiently (McCarthy & Anagnostou, 2004). Companies in a TFT-LCD supply chain can focus on only one or two steps in the supply chain while outsourcing the rest of steps to other companies. For instance, a TFT-LCD manufacturing company may receive orders from a notebook manufacturing company, which specifies the specification of the panels, and manufacture TFT-LCD modules according to the design. It also needs to find upstream companies to obtain the required equipment, material and components. On the other hand, for a notebook manufacturing company, it also needs to find one or several suitable TFT-LCD manufacturing companies to obtain the required TFT-LCD module for producing notebook computers. In consequence, the selection of the right companies for cooperation is important for maintaining a competitive edge. In addition, how to distribute the amount of purchases to the selected manufacturers is also a problem faced by the purchasing companies.

The rest of this paper is organized as follows. Section 2 introduces the TFT-LCD industry. Section 3 reviews some recent researches on supplier selection. FAHP and goal programming are discussed in Section 4. Section 5 proposes a fuzzy MCGP model applied to select TFT-LCD companies for downstream manufacturers. Section 6 presents a case study of a notebook manufacturer in Taiwan to verify the practicality of the model. Some concluding remarks are made in the last section.

2. The TFT-LCD industry

In this section, we review the manufacturing process of TFT-LCD, the supply chain of TFT-LCD and the TFT-LCD industry in Taiwan.

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2.1. Manufacturing process of TFT-LCD

TFT-LCD has a sandwich-like structure consisting of two glass substrates with a layer of liquid crystal inside. In fact, a TFT-LCD module consists of a TFT panel (with TFT-array substrate, liquid crystal and color filter substrate), a driving-circuit unit (with LCD driver IC (LDI) chips, multi-layer PCBs and driving-circuits) and a backlight and chassis unit (with backlight, lamp, light-guide panel (LGP) and chassis).

The manufacturing of TFT-LCD, as depicted in Fig. 1, can be categorized into four main processes: TFT array fabrication, color filter (BM) fabrication, color filter (RGB) fabrication, cell assembly and module assembly.

2.2. Supply chain of TFT-LCD

A supply chain is defined as "an integrated process wherein a number of various business entities (i.e., suppliers, manufacturers, distributors and retailers) work together in an effort to: (1) acquire raw materials/components, (2) convert these raw materials/components into specified final products, and (3) deliver these final products to retailers" (Beamon, 1998). Supply chain management is becoming more and more important in industries due to shortened product life cycles, rising manufacturing costs and globalizing market economies.

The TFT-LCD supply chain involves the domains of optics, semiconductor, electrical engineering, chemical engineering, mechanical engineering and material. The upstream of the TFT-LCD supply chain includes the equipment (e.g. photo/etch equipment) and the material and components (e.g. glass substrate, backlight module and driver IC). The midstream processes the material provided by the material/components suppliers, by using the equipment provided by equipment suppliers. Panels are first manufactured and then assembled into TFT-LCD modules. The modules are used by downstream manufacturers to make final products such as notebook computer, LCD monitors, etc.

To summarize, in order to gain competitive advantage, a company in the TFT-LCD supply chain, as in many other industries, needs to keep good cooperation with other firms in the supply chain to provide products more effectively and efficiently.

2.3. TFT-LCD and notebook industries in Taiwan

One of the most brilliant industries in Taiwan is in the TFT-LCD industry. With the success in the information and semiconductor industry over the past decade, Taiwan has a strong background and foundation for developing the TFT-LCD industry. Most of the TFT-LCD panels in the world are supplied by Taiwan, Korea and Japan. Japan is the technology leader, but it has changed its strategy from manufacturing to R&D in the TFT-LCD industry, especially for large size TFT-LCD, due to its high manufacturing costs. With the transfer of Japan's TFT-LCD technology to Taiwan and the competitive advantages of Taiwan in abundant capital, numerous downstream clients and a complete supply chain, the TFT-LCD industry is flourishing in Taiwan (Chang, 2005). Taiwan is the region with the second largest capacity in small-to-medium size TFT-LCD, and the largest in large size TFT-LCD. As panel manufacturers continue to build up new capacity with new-generation fabs, a larger capacity is becoming a fact soon.

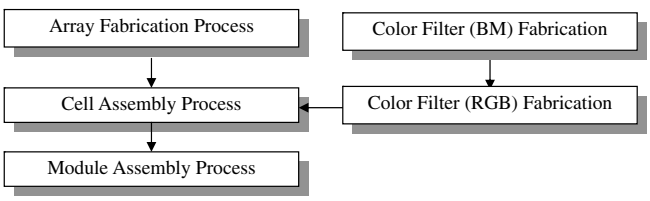

Fig. 1. TFT-LCD manufacturing process.

The case study in this paper is based on an anonymous notebook manufacturer in Taiwan in selecting the most suitable TFT-LCD manufacturer(s) for outsourcing. In recent years, demand for notebook computers continues to grow at a faster rate than that for desktop computers due to the portable characteristic of notebooks. Taiwan has two diversified businesses in notebooks: contract (OEM) manufacturing for the world's top brands such as Dell, HP and Toshiba, and own brand manufacturing such as Asus and Acer (People's Daily Online, 2004). It is an important base for the global production of notebook computers, and the global market share of notebooks manufactured by Taiwan firms was 73% in 2005 (DigiTimes Publication, 2006). Even though Taiwan firms have the majority of market share in notebook manufacturing, the profitability of the industry has been shrinking. To improve profit margins and to decrease labor and production costs, Taiwan manufacturers have been quick to relocate assembly lines offshore, and over 90% of Taiwan's manufacturers have set up production plants in China. However, the profit margin in the industry is expected to continue declining due to capacity expansion.

In conclusion, a notebook manufacturing company, in order to increase profit margin and to obtain satisfactory TFT-LCD modules, needs to find one or several suitable TFT-LCD manufacturing companies for cooperation. In addition, the distribution of the amount of purchases to the selected manufacturers should also be examined in order to keep competitive advantage in the global market.

3. Supplier selection problem

In the current business environment, global competition is an unpreventable fact, and customer demands are diversified. The result is progressively increased costs and sharply decreased profit. In consequence, purchasing has become a crucial job in establishing value-added contents of products and a vital determinant to ensure the profitability and survival of a company. Many companies are trying to reduce their costs while satisfying customer needs by strengthening their core competencies and outsourcing other functions. Selecting the right suppliers which can maintain a continuous supply relationship requires a careful assessment because suppliers have varied strengths and weaknesses.

The research on supplier selection is abundant. First publications can be traced back to the 1960s, and Weber, Current, and Benton (1991) and Ghodsypour and O'Brien (1998) did a comprehensive review on the past research. de Boer, Labro, and Morlacchi (2001) identified four research subjects within the research field of supplier selection: problem definition, formulation of criteria, prequalification and final selection. The latter two are mostly studied. The pre-qualification step is the process of reducing the set of suppliers to a smaller number of acceptable suppliers, and the methods that are often applied can be categorized into four kinds: categorical methods, data envelopment analysis (DEA), clustering analysis (CA), and case-based reasoning (CBR) system (de Boer et al., 2001). The final selection step is usually solved by five types of methods: linear weighting, total cost of ownership, mathematical programming (MP), statistics, and artificial intelligence (AI) (de Boer et al., 2001; Hong, Park, Jang, & Rho, 2005).

The simplest supplier selection method is the categorical method, by which each supplier characteristic is assigned good, satisfactory, neutral and unsatisfactory and then the total score for each supplier is summed up (Ghodsypour & O'Brien, 1998). Linear weighing method is one of the most common methods, and the concept is to give different weights to a number of criteria and to