

Research Article

Using MEC and FAHP to Establish an Evaluation Model for Food Processing Machinery Procurement

Tsung-Yu Chou ¹ and Juei-Ping Liao²

¹Department of Distribution Management, National Chin-Yi University of Technology, Taichung City 411, Taiwan

²Chung Shen Food Machinery Co., Ltd., Taichung City 411, Taiwan

Correspondence should be addressed to Tsung-Yu Chou; arthur@ncut.edu.tw

Received 5 August 2020; Revised 29 September 2020; Accepted 4 October 2020; Published 29 October 2020

Academic Editor: Kim-Hua Tan

Copyright © 2020 Tsung-Yu Chou and Juei-Ping Liao. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Industry 4.0 is a high degree of connection and integration of information and mechanical equipment. The goal of Industry 4.0 is to link equipment, production lines, factories, suppliers, products, and customers closely. With the continuous increase of smart manufacturing equipment, the responsibility of the purchasing department and purchasers will become heavier. Therefore, purchasers must understand these kinds of equipment and their functions in order to make a good decision. The objective of this paper is to establish a procurement decision support model. It presents corporate purchaser decision-making criteria as reference for the food processing machinery (FPM) manufacturing industry. Combining the concepts and methods of mean-end chain (MEC) and fuzzy analytic hierarchy process (FAHP), an MCDM model to select suitable machinery for the food processing industry was presented. Firstly, a hierarchical structure includes 2 factors, 7 criteria, and 25 subcriteria for FPM purchasers to select machines is constructed based on MEC analysis. Secondly, FAHP is used to solve the subjective weights of all criteria and subcriteria. Then, the key factors of FPM procurement were obtained. There are 50 FPM purchasers to be interviewed in first phase, and 50 AHP questionnaires were distributed to these purchasers in second phase. Fuzzy multicriteria decision analysis was carried out, and the top five most important attributes out of the 25 criteria were sorted out. They are switching cost, price, brand, professionalism of service personnel, and accessibility of after-sales services. This study uses actual industrial cases to verify the proposed method, and offers the practical purchasing decision support model based on the actual FPM purchaser and the manufacturer's product manager. It will enhance the practicality of the research. In addition, the lack of the literature makes it difficult to establish an evaluation model. This study uses MEC and FAHP to obtain evaluation criteria and establish evaluation models, which will be the original contribution of the research.

1. Introduction

After years of development, Taiwan's food industry has gradually shifted from providing agricultural products and primary processing food for export to meet the demand of food and improve the quality of life. With the increase of income, demand for health care, and convenience of life, the food industry is now providing foods in all major channels. In recent years, a number of food manufacturers in Taiwan maintain between 5,800 and 6,200, indicating that the development of food industry is stable. In terms of the size of manufacturers, 99% of Taiwanese food factories are small or medium-sized enterprises. According to the data of the

Ministry of Economic Affairs, the production value of Taiwan's food and beverage manufacturing industry (excluding tobacco) was NT\$ 602.2 billion in 2018, which was nearly 4.6% of the manufacturing production value. This value ranks eighth in the manufacturing industry and can be regarded as an important industry in Taiwan [1].

Taiwan is known as a gourmet kingdom. Due to its special geographical location, a variety of crops grow in this island and this creates a great unique food culture. To satisfy the taste of consumers, the food manufacturing industry continues to innovate new cuisine and food processing methods. Therefore, the food machinery industry plays an important role in the food development and production

process. Due to the technological advancement in food processing, the production of FPM has been upgraded from semiautomatic to fully automated and speeded up the manufacturing time. For the requirement of hygiene and accuracy, the manufacture of the food processor is moving from tradition to precision machinery. The market for food process machine has changed. Customers tend to accept high-quality equipment, such as stainless, automatic, high speed, and maintaining the raw material quality during processing. Although manufacturers are striving to make better equipment through R&D, they still could not design successful marketing strategies if they do not get the accurate needs for customers and factors affecting customer's purchasing decision.

The goal of Industry 4.0 is to integrate existing manufacturing resources, sales processes, and big data to establish an industry that can quickly respond to the market needs, produce the right products, and reduce the costs. It includes three major projects: smart factory, smart production, and smart logistics. Industry 4.0 is an innovative thinking. It includes technological innovation, product innovation, model innovation, and organizational innovation. It also transforms mass production to personalized customization, transforms production-oriented manufacturing to service-oriented manufacturing, and the previously capital investment can bring industrial innovation through the application of a new generation of information technology. In addition, Industry 4.0 also depends on the upgrading of purchasing department. As smart manufacturing equipment continues to increase, the responsibility of considering how new machines or parts can work together with existing systems has fallen on the purchasing department. Therefore, in this Industry 4.0 era, purchasing managers must understand and develop evaluation criteria better when purchasing equipment in order to make correct decisions.

To gain an edge and success in a business-to-business market, companies must understand the buying behavior of their customers [2]. Kotler and Keller [3] pointed out that organizational markets consist of organizations that have the needs for products and services, including for-profit enterprises, institutions, and organizations. Products and services purchased by organizations are often considered as investment, which are invested to produce other goods and services that would later be sold to other consumers. In comparison with consumer markets, the transaction amount of organizational markets is relatively large; for this reason, organizational buyers not only need professional knowledge and purchasing training but also need to follow their respective procurement policies. An organization often faces different evaluation pressures when making purchasing decisions. The analytic hierarchy process (AHP) enables researchers to better understand the nature of the problem and make more accurate decisions as it allows them to break complex problems into small ones and classify them by establishing dendritic hierarchical structures. Thus, academia and practice apply AHP widely when they evaluate and select the most suitable solution with multicriteria decision analysis.

The research on purchasing decisions for FPM is insufficient. As the FPM market becomes increasingly competitive and customers' demand for quality and unique machinery continues to increase, the customer-perceived value of product remains underexplored. Therefore, this study addressed the literature gap to explicate the value of FPM selected by customers. Studies on user value have mostly adopted means-end chain (MEC) approaches to explore topics such as the value of participating in recreation and physical exercise [4, 5] and the value of buying behavior [6]. MEC is a methodology for examining customer behavior and value that is typically used in the development of advertising strategies, market segmentation, and brand management to investigate the meanings consumers attribute to products, services, or customer consumption behaviors [7], as well as the relationships between these meanings and their perceived value [8, 9]. This study adopted the MEC to investigate consumers' perceived value of FPM and attributes of purchasing decision in Taiwan.

The purpose of this research is to establish a procurement decision support model. This study conducted an investigation for procurement decision-making and adopted multicriteria evaluation methods to make a comprehensive assessment of the factors that affect such procurement. By this way, this study intends to find out more factors affecting decision-making and enhance the integrity and objectivity of the decision-making models. The traditional decision-making analysis method based on precise numerical values could no longer fulfil the complex human mind decision-making. The organizational procurement process is a complex and ambiguous procedure, which involves many people and criteria. The change of environments or human thinking could be recognised as uncertain concepts, and this could be described and expressed in a fuzzy way.

To solve the ambiguous problem, this study proposes a new method. The novelties of this method are as follows: (1) by in-depth interviewing with professional purchasers and discussion from committees, this brings out closing to actual situation attributes. (2) The integration of MEC and FAHP will make the results more objective. (3) The standard weights of purchasing decision attributes obtained from interviews and surveys are more objective.

The research questions of this article are as follows:

- (1) How to establish a systematic procurement evaluation framework to help purchasers of FPM to improve procurement performance?
- (2) How to combine MEC and fuzzy AHP methods and extend them to the multicriteria decision-making evaluation of FPM procurement?
- (3) How to identify technical improvements when the information is uncertain and the data are poor?

This research has made four contributions to FPM buyers and manufacturers. First, this approach of integrating MEC and FAHP provides a systematic framework for purchasing decision makers when purchasing machinery. In addition, based on the relevant literature and personal interviews, this article proposes the evaluation criteria used in

procurement. Third, the purchase evaluation criteria put forward by customers will assist manufacturers in technological improvement and design direction. Finally, this study uses actual cases to verify the proposed methods and guidelines, so that readers can understand and simplify the application. The structure of this article is as follows. Section 2 introduces the literature review, and Section 3 introduces the methodology. Section 4 introduces case applications and discussions. Finally, Section 5 introduces the conclusions and recommendations of future research.

2. Literature Review

2.1. Organizational Buying Behavior and Decision-Making Process. It is important and necessary to understand the purchasing behavior of client companies. However, it is not easy to map out their purchasing behavior pattern for organizational buying behavior is often a complex process involving multiple stages, purchasers, departments, and objectives [2]. This dynamic and complex process often presents a series of complex problems and situational factors to the seller as they directly or indirectly affect corporate purchasing behaviors. Industrial procurement activities are often undertaken to purchase specific goods and services through a group within the organization involved in purchasing decisions. This is called a procurement center [10, 11].

It is of great importance for suppliers to understand the behavioral pattern involved in organizational buying. Suppliers can provide appropriate merchandise and marketing service portfolios through figuring out procurement processes. Organizational purchasing behavior not only acquire raw materials, components, or products with the lowest price or cost but also aim to know well about the supply sources, create the procurement plan, and confirm the quality of goods [12]. Purchasing is about buying a needed quantity of merchandise at reasonable prices from the right suppliers [13]. The main difference between the industrial market and the consumer market is there are a lot people involved in purchases, the commodity attributes are complex, and purchasing decisions are made by a team [3]. While organizational buying is part of consumer behaviors, there are still differences between individual and organization purchasing behaviors. Organizations purchase products and services to create profits, and the decision-making process involves complex personnel interactions and achieves both personal and organizational goals. Webster and Wind [10] proposed that procurement decision processes need to be carried out in accordance with corporate procurement policies, which not only involves meeting corporate needs but also includes valuation, proposal, and contract formulation. Kotler et al. [14] referred to the task force that organizes procurement operations as a procurement center and defined the center as all individuals or groups that have a common goal, participate in the decision-making process, and assume the risk of decision-making. Organizational procurement behavior involves a complex decision-making process that consists of different personnel, goals, and conflicting. The decision-making

process usually takes time, requires information from a variety of sources, and involves all departments of an enterprise [10]. Previous research on industrial and organizational buying behaviors has developed industrial purchasing models based on the research proposed by Robinson et al. [15] dividing organizational purchase tasks into three levels, namely, straight rebuy, modified rebuy, and new-task purchase. Johnston and Lewin [2] studied the procurement behavior and proposed an integrated framework in which procurement participants may change their purchasing behavior because they have different knowledge, motivation, perception, experience, personal style, and risk preferences. Heide and Weiss [16] and Sheth [11] also found the behavioral characteristics of the procurement process for specific industries based on the general model of procurement decisions.

Organizational purchases often start from a sample trial before they decide whether to purchase large quantities from the same supplier for the long term. After the trial approval, purchasing units will propose certain brands, specifications, prices, delivery methods, and payment terms and then negotiate with the manufacturer. If purchasing units and suppliers reach agreements, the purchasing unit will make purchase from the identified suppliers, which is often called "straight rebuy." Robinson et al. [15] proposed "purchase phase," and these phases (or steps) represent activities that are often performed in organizational purchases. These activities include (1) understanding the needs and general solutions, (2) identifying characteristics and quantities, (3) describing features and quantities, (4) looking for potential sources, (5) obtaining and analyzing suppliers' proposals, (6) evaluating recommendations and selecting suppliers, (7) selecting and ordering, and (8) feedback and evaluation. Similarly, Kolter and Keller [3] also proposed stages of organizational market buying decision process: (1) detecting issues, (2) identifying needs, (3) confirming product specifications, (4) looking for suppliers, (5) requesting quotation, (6) selecting suppliers, (7) formally placing orders, and (8) evaluating performances. Therefore, the aforementioned purchase procedure reveals that in the various purchasing behavior patterns, complete information and feasible plans constitute as important factors that assist the organization in making purchasing decisions.

To conclude, consumers assess decisions based on their perception of problems and the information they collect in the purchase decision-making process. This study aims to provide consumers an evaluation model as a basis for purchasing. Based on the procurement procedure, this study establishes a complete and objective purchase decision-making model for purchasers as their ground rules, which will be an important contribution to corporate procurement decisions.

2.2. Means-End Chain (MEC) Analysis. MEC is a method that combines qualitative and quantitative analyses in order to meaningfully explore customers' cognitive structures in decision-making. It is an analysis, is a qualitative method for investigating individuals' general cognitive structures in

decision-making without requiring a large sample of respondents, and is usually used to investigate the motivations of customers' purchasing decisions [17–19]. MEC can be used to check the influence of personal value on personal behavior. The MEC explains how consumers (who obtain satisfactory satisfaction from a product or service) consider the attributes or functions of the product or service and the consequences of using the product or service before purchasing.

The method assumes that customers do not purchase a product for their own sake, but for the benefits that accrue. Values are pivotal beliefs that reflect the individual and his/her behaviors [20]. Therefore, the goal of MEC analysis is to determine the attributes that decision makers believe which are relevant to the purchase decision and the underlying reasons for this correlation. That is, MEC captures the abstract meaning of various products and analyzes the product attributes perceived by customers and the consequences of using them to obtain a certain value [21].

When conducting MEC analysis, the interview content can be broken down into product/service attributes and then analyzed. Therefore, in the context of services, MEC analysis can be used to investigate the attributes of the service, the different consequences caused by the use of the service, and the cognitive connection between the customer's personal value. In the MEC framework, several elements are usually included: attributes, functional consequences, and values [9]. Although the MEC method was originally used to test consumer motivation, it has also been applied to research in various industries [19, 22, 23]. We think it is suitable for our research because it can help us discover the purchasing needs of the organization's purchasing decision makers. In this study, attributes are the unique characteristics of food manufacturing machinery purchased by food manufacturers, such as price and service, machine reliability, or power system. Functional consequences represent qualitative results directly related to service use, such as work efficiency or power management. Values, as the highest-level elements of MECs, represent the purchaser's cognitive value of the needs of the enterprise, such as suppliers or machine specifications. By purchasers' subjective decision chains, from attributes, over consequences, to values, MEC analysis provides a decision-making framework for AHP analysis.

3. Research Methodologies

3.1. Proposed Model. This section describes the construction of an evaluation model incorporating the MEC and FAHP that can be applied effectively, and is scientific and systematic. The proposed integrating MEC and FAHP method can be summarized as follows (Figure 1).

3.2. MEC Analysis. This research is based on MEC analysis. First of all, the ladder interview method is used for data collection, and then the content analysis method is used to construct a hierarchical structure to determine the three levels of customers' choice attributes, factors, and value.

Step 1: establishing a committee to conduct consumer interview planning and questionnaire design.

Invite industry experts and scholars to establish committees to discuss the main direction of interview, interview outlines, and interviewers training. Select the members of the committee to analyze the content of the interview data.

Step 2: consumer interview.

The ladder interview method is one of the data collection and analysis methods in this article. It is an interviewing technique where a seemingly simple response to a question is pushed by the interviewer in order to find subconscious motives [24]. This interview method can convert product attributes into meaningful links, which is one of the most commonly used methods of MEC [25].

Reynolds and Gutman [24] proposed that at least 20 samples are required for the ladder interview. Since the ladder interview method requires the respondents to clearly express more abstract thinking, the interviewer should be educated and trained before the interview. Use one-on-one in-depth interviews, and use direct elicitation to understand the user's considerations step by step. Each interview takes about 30 minutes to 60 minutes. Then, through association and analysis to conduct the possible consequences of these attributes, and finally from these consequences, infer the value generated, and explore the link between them [26]. This study will use this method to deduce the factors that each attribute belongs and the value it generates.

Step 3: data analysis and establishing the decision-making framework.

Content analysis is the MEC's tool for analyzing interview data [24]. The purpose is to simplify the content of the interview. Content analysis makes complex and tedious interview data, makes objective and systematic classification, and extracts important relevant information content for quantitative presentation [27]. Reynolds and Gutman [24] proposed that the ladder method must cooperate with the content analysis method. First, the interview data of the interviewees were collected. According to the verbatim content, several professionals acted as coders. After stem classification and coding analysis, they understand the customer's opinion and establish customer decision attribute framework.

A reliability test was conducted for interjudge reliability, in which all ratters independently coded the same data according to the same coding procedure. Similar coding consequences between ratters showed higher agreement; those that were not similar had lower agreement. Subsequently, the reliability of the study was estimated using the reliability equation, which is expressed as follows:

$$\text{reliability} = \frac{(n \times m)}{[1 + (n - 1) \times m]}, \quad (1)$$

where n is the number of coders and m is mean interrater agreement level.

Reliability exceeded the threshold 0.85 recommended by Kassarian [27] indicated high reliability.

3.3. FAHP. This study combines AHP with the fuzzy set theory to construct for decision-making in FPM procurement. The steps are explained as follows:

Step 4: establishing a fuzzy pairwise comparison matrix.

The fundamental scales are used to assess the relative importance of the criteria and subcriteria. Then, these pairwise comparison matrices containing all criteria and subcriteria are established. After completion pairwise comparison, the importance will be converted into linguistic values of TFNs. The linguistic value will be characterized by the TFN defined on [0, 1] in this study [28]. For instance, extremely important = (1, 1, 1), important = (0.75, 1, 1), slightly important = (0.5, 0.75, 1), average = (0.25, 0.5, 0.75), not that important = (0, 0.25, 0.5), unimportant = (0, 0, 0.25), and extremely unimportant = (0, 0, 0).

Assume that there are f experts in a committee. These experts are responsible for assessing the relative importance of k criteria and the relative importance of subcriteria under each criterion. Let \tilde{b}_{pqr} , $\forall p < q$, $r = 1, 2, \dots, f$, and $p, q = 1, 2, \dots, k$, be the TFN relative importance of criteria C_p to C_q given by expert E_r . The fuzzy pairwise comparison matrix Br of the TFN relative importance of criteria C_p to C_q given by expert E_r can be obtained:

$$\begin{aligned} \tilde{B}_r &= [\tilde{b}_{pqr}], \\ \tilde{b}_{pqr} &= 1, \quad \forall p = q, \\ \tilde{b}_{pqr} &= \frac{1}{\tilde{b}_{qpr}}, \quad \text{if } p > q. \end{aligned} \quad (2)$$

By using similar steps, pairwise comparison matrices of the relative importance of subcriteria under each criterion given by expert E_r can be obtained.

Step 5: making consistency testing.

Consistency testing is an important issue of the AHP. The consistency ratio (C.R.) is defined as follows:

C.R. = C.I./R.I., where C.I. and R.I. are the consistency index and random index. And $C.I. = (\lambda_{\max}^y - k)/k$, where k is the number of criteria compared, and λ_{\max}^y is the maximum eigenvalue of pairwise comparison matrix $\tilde{B}_r = [\tilde{b}_{pqr}]$.

The R.I. value can be found from Table 1. When the C.R. is less than or equal to 0.1, the consistency test is successful [29].

Step 6: calculating the fuzzy weight value of all criteria.

Let \tilde{a}_{ijt} , $t = 1, 2, \dots, f$, and $i, j = 1, 2, \dots, k$, be the TFN relative importance of criteria C_i to C_j given by

expert E_t . The fuzzy pairwise comparison matrix A of the relative importance of all criteria given by all s experts can now be obtained:

$$\begin{aligned} \tilde{A} &= [\tilde{a}_{ij}], \\ \tilde{a}_{ij} &\cong (\tilde{a}_{ij1} \otimes \tilde{a}_{ij2} \otimes \dots \otimes \tilde{a}_{ijf})^{1/f}, \quad \text{if } i < j, \\ \tilde{a}_{ij} &= 1, \\ \forall i &= j \tilde{a}_{ij} = \frac{1}{\tilde{a}_{ji}}, \quad \text{if } i < j. \end{aligned} \quad (3)$$

By using the similar steps, the fuzzy pairwise comparison matrices of the TFN relative importance between subcriteria can be obtained. This way, the fuzzy weight of i th evaluation dimension can be expressed to be $\tilde{w}_i = (w_{il}, w_{im}, w_{iu})$. The fuzzy weight for the hierarchy of subcriteria is constructed in a similar way.

Step 7: defuzzification of fuzzy weight values.

The GMIR method [30] is relatively simple in terms of calculation, and it is an effective defuzzification method, so this study adopts this method when performing defuzzification of fuzzy weight values. Make $\tilde{w}_i = (w_{il}, w_{im}, w_{iu})$, $\forall i = 1, 2, \dots, k$, TFN weights, so the mathematical expression for k explicit weight values after defuzzification is shown as follows:

$$w_i = \frac{(w_{il} + 4w_{im} + w_{iu})}{6}, \quad \forall i = 1, 2, \dots, k. \quad (4)$$

Step 8: standardizing the weight values.

To compare the relative importance of the criteria at each hierarchy and sort the importance weight values, this study normalizes k explicit weight values after the aforesaid defuzzification. The mathematical expression is shown as follows:

$$w_g = \frac{w_i}{\sum_{i=1}^k w_i}, \quad \forall i = 1, 2, \dots, k. \quad (5)$$

Step 9: calculating the final aggregation ratings.

Let w_g , $g = 1, 2, \dots, k$, be the weight of criterion C_g . Let v_{gh} , $g = 1, 2, \dots, k$, $h = 1, 2, \dots, n_g$ be the weight of the subcriterion C_{gh} . The aggregate ratings u_{gh} of the subcriterion C_{gh} can be calculated as

$$u_{gh} = w_g \times v_{gh}, \quad g = 1, 2, \dots, k, \quad h = 1, 2, \dots, n_g. \quad (6)$$

4. Empirical Study

4.1. Establishing a Committee to Conduct Consumer Interview Planning and Questionnaire Design. Invite five experts (including product manager $\times 2$, purchasing manager $\times 2$, and vice president of purchasing $\times 1$) and five scholars familiar with the industry to establish committees. This committee will discuss the main direction of interview, interview outlines, and interviewers training. Aside from

product attributes, customers consider the quality of services or products before they purchase. The interview outlines include purchaser job responsibility, decision factors when purchasing FPM, factor classification, and the value that company can obtain.

4.2. Consumer Interview. This research adopts the ladder interview method to conduct interviews. Keep asking questions in a direct way, until the respondent does not want to answer, and get the ultimate value. In this study, FPM purchasers in Taiwan were selected as research participants, and the survey was conducted by means of convenience sampling. There are 50 purchasers to be interviewed from Jan. to Feb. 2020. The rate of male respondents is 61.2%, and 65.6% of the respondents were purchasing managers. About 70% of the respondents had more than 10 years of purchasing experience.

Use one-on-one in-depth interviews, and use direct elicitation to understand the user's considerations step by step. Each interview takes about 30 minutes to 60 minutes. Then, through association and analysis to conduct the possible factors of these attributes, and finally from these factors to infer the value generated.

4.3. Data Analysis and Establishing the Decision-Making Framework. First, collect the interview data of the interviewee. After 4 coding experts (2 are research assistants who have worked in the field of machinery manufacturing, MEC, and content analysis related research, and other 2 are with more than 8 years of sales experience and high contact with customers) according to verbatim content for stem classification and coding analysis, the customer's attributes-dimensions-value hierarchy are obtained. The reliability of the study is 0.91 exceeded the threshold 0.85 recommended by Kassirjian [27] indicated high reliability.

According to the suggestions of scholars Gengler and Reynolds [31], the cutoff value can be determined based on 5% of the sample, so the cutoff value of this study is 3 ($=50 \times 5\%$). In other words, the number of direct links mentioned by different respondents on the same ladder must be more than 3 times to confirm their link relationship. The higher the number of links, the higher the degree of linkage. The main purpose of setting the cutoff value is to show a stable link between attributes and factors, and to avoid weak relationships that complicate the overall link. Therefore, we can obtain the attributes contained in each factor by link judgment, and understand the value linked by each dimension.

The buyers confirm the supplier before they start to discuss products. Therefore, this study conducts discussions and analyses in the perspectives of suppliers (V1) and product specifications (V2). In terms of suppliers, purchasers determine the price (F11) and the service of manufacturers (F12), which has been mentioned in previous research and interview in this study. Specifically, the price (A111), brand (A112), and switching cost (A113) of FPM are the major attributes that customers consider when they decide whether to buy a food processing machine.

Regarding the service provided by suppliers, the attributes to which purchasers pay much attention to include the accessibility of after-sales services (A121), relationships with suppliers (A122), the professionalism of service personnel (A123), and word of mouth of customers (A124). In terms of product specifications, the following attributes are to be analyzed: operational performance (F21), appearance (F22), operating interface (F23), power management and safety (F24), and auxiliary equipment (F25). The operational performance includes operating speed of a machine (A211), machine reliability (A212), combustion efficiency of a furnace (A213), noise (A214), drive efficiency of a motor (A215), and heat dissipation of a machine (C216). In terms of appearance, the attributes include exterior design (A221), volume (A222), and shell material (A223). The attributes for the operating interface include expandability of a machine (A231), ease of machine assembly and disassembly (A232), and ease of operation (A233). The power management and safety are often considered from the electromechanical aspect of a machine, including power system safety (A241), safety certification (A242), operating safety protection (A243), and warning reminder (A244). Lastly, customers also value auxiliary equipment, including instructions manual (A251) and provided accessories (A252). Analysis of the interview transcripts yielded is detailed in Table 2, and the hierarchy diagram for FPM procurement is shown as Figure 2.

4.4. AHP Data Collection, Analysis, and Discussion. In this section, the second phase of AHP data collection and analysis will be implemented. Respondents who conducted the first phase of MEC interviews are asking whether they are willing to receive the AHP questionnaire. Total of 25 questionnaires were distributed, in which 20 of them were collected and valid with a recovery rate of 80%.

4.4.1. Consistency Check. The AHP uses the consistency ratio (C.R.) as a criterion for measuring the consistency of paired matrices. This study evaluates the consistency of paired matrices, including two constructs, seven dimensions, and 25 criteria, and the CI value. According to Saaty [29], if $C.I. \leq 0.1$, it indicates that the consistency of paired matrices is satisfactory; if $C.R. \leq 0.1$, it indicates that the paired matrices fall in the consistency range, so the decision-making behavior can continue. Seen from the consistency results, the C.I. and C.R. values of each dimension and each item are less than 0.1, indicating that the hierarchical framework of the study and the paired matrix constructed based on the valid questionnaire have a good consistency.

4.4.2. Weight Results. The weights of evaluation dimensions and subcriteria are calculated through the FAHP, and the results are shown in Table 3. At the hierarchy of main criteria, the evaluated factors are supplier (V1) and product specification (V2), of which purchasers consider the supplier (V1) to be more important than the product specification (V2). Among the subcriteria under the supplier (V1), the

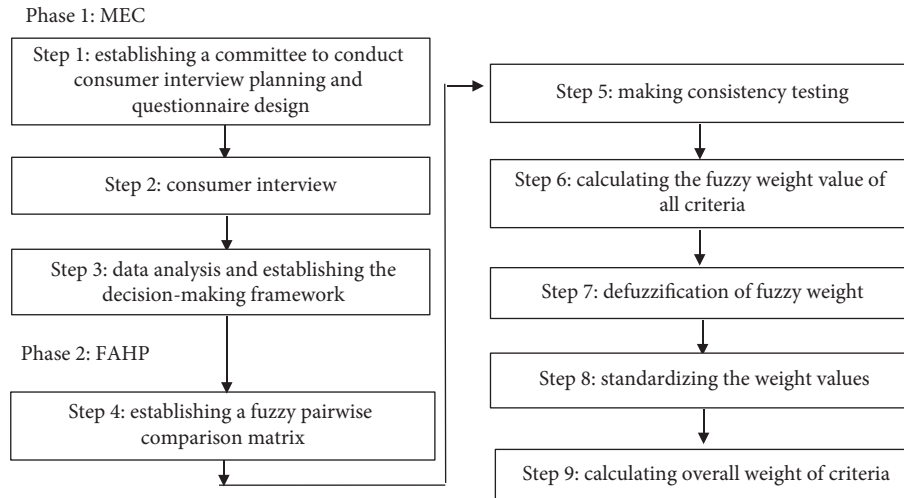


FIGURE 1: Framework of the proposed methodology.

TABLE 1: Random index.

k	1	2	3	4	5	6	7
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32

TABLE 2: Frequency of each attribute, consequence, and value.

Values (V)	Freq.	Factors (F)	Freq.	Attributes (A)	Freq.		
V1 supplier	46	F11 price	49	A111 price	49		
				A112 brand	46		
				A113 switching cost	44		
				A121 accessibility of after-sales service	33		
				A122 relationship with suppliers	30		
		F12 service	45	A123 professionalism of service personnel	23		
				A124 word of mouth of customers	25		
				F21 operational performance	40	A211 operating speed of machine	30
						A212 machine reliability	34
						A213 combustion efficiency of furnace	33
A214 noise	28						
A215 drive efficiency of a motor	21						
V2 product specification	39	F22 appearance	33	A216 heat dissipation of a machine	18		
				A221 exterior design	30		
				A222 volume	37		
				A223 shell material	34		
				A231 expandability of a machine	20		
		F23 operation	39	A232 ease of assembly and disassembly	23		
				A233 ease of operation	22		
				A241 power system safety	40		
				A242 safety certification	35		
				A243 operational safety protection	36		
F24 power management	38	A244 warning reminder	19				
		A251 instructions manual	28				
		F25 auxiliary	25	A252 provided accessories	23		

price (F11) is more important than the manufacturer service (F12). For product specification, the operational performance (F21) is more important than power management and safety (F24). The operating interface (F23) is ranked third. Among the comparisons of 25 subcriteria, the most important factor is the switching cost (A113), followed by

price (A111), brand (A112), the professionalism of service personnel (A123), and the accessibility of after-sales services (A121). The relatively unimportant top five factors are provided accessories (A252), instructions manual (A251), exterior design volume (A221), operating speed (A221), and volume (A222).

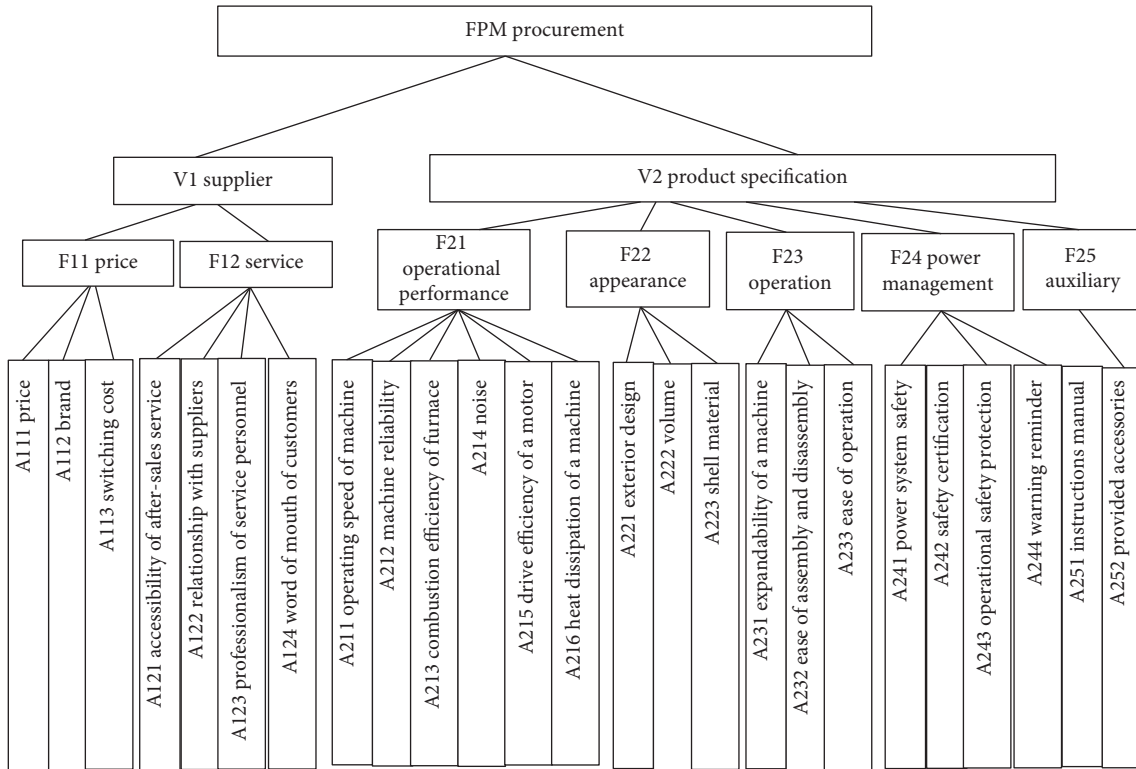


FIGURE 2: Hierarchy diagram for FPM procurement.

TABLE 3: Relative weights of evaluative criteria.

Criteria and subcriteria	Fuzzy numbers of weights	Defuzzification	Standardized weights	Integrated weights	Sorting by criteria	Sorting by hierarchies
V1	(0.414, 0.578, 0.783)	0.584833	0.604167		1	1
V2	(0.288, 0.375, 0.511)	0.383167	0.395833		2	2
F11	(0.539, 0.709, 0.920)	0.715833	0.690403	0.417119	1	1
F12	(0.423, 0.288, 0.351)	0.321	0.309597	0.187048	2	2
F21	(0.187, 0.262, 0.361)	0.266	0.263236	0.104198	1	3
F22	(0.071, 0.094, 0.130)	0.096167	0.095167	0.03767	5	7
F23	(0.156, 0.216, 0.359)	0.229833	0.227445	0.09003	3	5
F24	(0.188, 0.261, 0.359)	0.265167	0.262411	0.103871	2	4
F25	(0.111, 0.151, 0.205)	0.153333	0.15174	0.060064	4	6
A111	(0.239, 0.313, 0.413)	0.31733	0.16336	0.06814	2	2
A112	(0.203, 0.275, 0.384)	0.28117	0.14474	0.06038	3	3
A113	(0.273, 0.376, 0.512)	0.3755	0.19331	0.08063	1	1
A121	(0.180, 0.235, 0.304)	0.23733	0.12218	0.02285	2	5
A122	(0.147, 0.189, 0.243)	0.191	0.09833	0.01839	4	7
A123	(0.227, 0.307, 0.417)	0.312	0.16062	0.03004	1	4
A124	(0.174, 0.224, 0.299)	0.22817	0.11746	0.02197	3	6
A211	(0.088, 0.118, 0.135)	0.115833	0.022728	0.002368	6	22
A212	(0.435, 0.455, 0.473)	0.45467	0.08921	0.0093	1	9
A213	(0.231, 0.278, 0.301)	0.274	0.053762	0.005602	2	13
A214	(0.192, 0.208, 0.213)	0.206167	0.040453	0.004215	5	19
A215	(0.244, 0.257, 0.269)	0.256833	0.050394	0.005251	3	15
A216	(0.210, 0.248, 0.272)	0.245667	0.048203	0.005023	4	16
A221	(0.192, 0.241, 0.314)	0.245	0.048072	0.001811	3	23
A222	(0.269, 0.362, 0.486)	0.367167	0.072043	0.002714	2	21
A223	(0.274, 0.380, 0.518)	0.385333	0.075607	0.002848	1	20
A231	(0.242, 0.343, 0.506)	0.353333	0.069329	0.006242	2	11
A232	(0.193, 0.266, 0.372)	0.2715	0.053272	0.004796	3	17
A233	(0.251, 0.361, 0.506)	0.366833	0.071978	0.00648	1	10

TABLE 3: Continued.

Criteria and subcriteria	Fuzzy numbers of weights	Defuzzification	Standardized weights	Integrated weights	Sorting by criteria	Sorting by hierarchies
A241	(0.507, 0.531, 0.554)	0.53083	0.10416	0.01082	1	8
A242	(0.179, 0.229, 0.303)	0.233	0.045718	0.004749	4	18
A243	(0.207, 0.260, 0.327)	0.262333	0.051473	0.005347	3	14
A244	(0.215, 0.278, 0.355)	0.280333	0.055005	0.005713	2	12
A251	(0.101, 0.134, 0.154)	0.131833	0.025867	0.001554	1	24
A252	(0.088, 0.118, 0.135)	0.115833	0.022728	0.001365	2	25

4.4.3. *Marketing and Response Strategies of Manufacturers.* Data analysis has shown that the first consideration for manufacturers in purchasing food processing machines is the switching cost mainly because FPM is not only a capital property but also a durable asset due to its long-term use and high costs. To maintain production without interruption, it is impossible for a factory to replace machinery at will. If a machine needs to be replaced, the losses caused by the replacement must be taken into account, i.e., the loss caused by the proficiency of staff and the machinery use habit, so the switching cost is the first consideration of food manufacturers in purchasing machinery. Based on these, manufacturers that are new in the market should propose a plan to reduce the switching cost of customers. This way, the manufacturers are more likely to attract customers to replace used machinery with new ones.

In addition, price is also an important factor. Its importance has been revealed in the factor of the conversion cost. Its importance is also implied in the FPM market. Manufacturers need to break the price competition and provide differentiated goods, to which the research and development department should pay attention to. It is of vital importance for traditional FPM factories to maintain normal operation of their machines. Therefore, factories value the following factors: reliability, power system and safety, ease of operation, and expandability of a machine, which are all under the criteria of product specifications. The research results indicate that it is an indispensable and important task for manufacturers to group customer service staff or provide timely training to customers or employees.

5. Conclusions

There are very few literature studies studied on corporate procurement evaluation models, even more less for food manufacturing companies. It is very important to assist companies to have a basis when purchasing machinery, and to guide companies to use evaluation models to assist decision-making. Therefore, this study uses the method of in-depth interviews and uses the advantages of triangular fuzzy numbers to deal with the uncertainty of human opinion. This results a new method based on MEC and FAHP to simplify the decision-making process of commodity procurement.

Most corporate purchasers do not use evaluation models to make objective decisions. However, it is necessary to guide enterprises to use relevant technologies to use an objective

and systematic evaluation model to assist decision-making. Therefore, this study uses the MEC analysis method to build a practical evaluation framework, and then combines the advantages of FAHP to deal with the uncertainty of human opinions. This will reduce the company's decision-making costs. In this study, the method integrates MEC and FAHP, and 9 steps are designed to obtain the priority of customer needs. Buyers attach importance to the top five attributes of food manufacturing machine tools: switching cost, price, brand, professionalism of service personnel, and accessibility of after-sales services.

The method proposed in this research provides the following theoretical and practical contributions for the purchaser and manufacturers:

- (1) The application of this model to the FPM industry is novel
- (2) When the purchasing team wants to improve purchasing performance, the model will provide a reference
- (3) This paper develops this practical decision evaluation model based on the actual purchaser and the machine manufacturer's negotiation
- (4) This study uses actual industrial cases in Taiwan to verify the proposed method, which enables companies to evaluate according to their needs

For the future research direction, it is suggested that the researcher can increase the survey of other function-used machinery to improve the purchasing efficiency of the purchaser. In addition, combining other methods or technologies will enhance the objectivity of the model. Finally, there are two limitations in this research. First, different companies have different needs, so they might adjust the evaluation criteria to meet their own product procurement situations. Secondly, this article applies the proposed method to FPM case studies. It could also be applied in various situations in many industries. Finally, this study uses fuzzy theory as the calculation tool to design the method, and it could also be carried out by using rough theory or neural network methods.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

- [1] Bureau of Foreign Trade, *Ministry of Economic Affairs*, Bureau of Foreign Trade, Taipei, Taiwan, 2016, <http://cus93.trade.gov.tw/FSCI/Retrieve%20date:2019.03>.
- [2] W. J. Johnston and J. E. Lewin, "Organizational buying behavior: toward an integrative framework," *Journal of Business Research*, vol. 35, no. 1, pp. 1–15, 1996.
- [3] P. Kotler and K. L. Keller, *Marketing Management*, Prentice-Hall, Upper Saddle River, NJ, USA, 12th edition, 2006.
- [4] X. Lin, Z. Guo, and J. D'Ambrab, "Analyzing consumer goal structure in online group buying: a means-end chain approach," *Information & Management*, vol. 54, no. 8, pp. 1097–1119, 2017.
- [5] L. C. Uijl Den, G. Jager, C. De Graaf, and S. Kremer, "Exploring the functional mealtime associations of older adults through consumer segmentation and a means-end chain approach," *Appetite*, vol. 107, pp. 613–622, 2016.
- [6] B. Kim, S. S. Kim, and B. King, "The sacred and the profane: identifying pilgrim traveler value orientations using means-end theory," *Tourism Management*, vol. 56, no. 3, pp. 142–155, 2016.
- [7] S. Matook, "Conceptualizing means-end chains of user goals as networks," *Information & Management*, vol. 50, no. 1, pp. 24–32, 2013.
- [8] J. Gutman, "A means-end chain model based on consumer categorization processes," *Journal of Marketing*, vol. 46, no. 2, pp. 60–72, 1982.
- [9] J. C. Olson and T. J. Reynolds, "Understanding consumers' cognitive structures: implications for advertising strategy," *Advertising and Consumer Psychology*, vol. 1, pp. 77–90, 1983.
- [10] F. E. Webster and Y. Wind, "A general model for understanding organizational buying behavior," *Journal of Marketing*, vol. 36, no. 2, pp. 12–19, 1972.
- [11] J. N. Sheth, "A model of industrial buyer behavior," *Journal of Marketing*, vol. 37, no. 4, pp. 50–56, 1973.
- [12] S. F. Heinritz and P. Farrell, *Purchasing: Principles and Applications*, Prentice-Hall, Upper Saddle River, NJ, USA, 1981.
- [13] M. R. Leenders, H. E. Fearon, and W. B. England, *Purchasing and Materials Management*, Homewood, Ill., R.D Irwin, Chicago, IL, USA, 1989.
- [14] P. Kotler, S. H. Ang, S. M. Leong, and C. T. Tan, *Marketing Management -An Asian Perspective*, Prentice-Hall, Upper Saddle River, NJ, USA, 3rd edition, 2004.
- [15] P. J. Robinson, C. W. Fairs, and Y. Wind, *Industrial Buying and Creative Marketing*, Allyn & Bacon, Boston, MA, USA, 1967.
- [16] J. B. Heide and A. M. Weiss, "Vendor consideration and switching behavior for buyers in high-technology markets," *Journal of Marketing*, vol. 59, no. 3, pp. 30–43, 1995.
- [17] P. Guenzi and G. Troilo, "Developing marketing capabilities for customer value creation through marketing-Sales integration," *Industrial Marketing Management*, vol. 35, no. 8, pp. 974–988, 2006.
- [18] T. Schaefers, "Exploring carsharing usage motives: a hierarchical means-end chain analysis," *Transportation Research Part A: Policy and Practice*, vol. 47, no. 1, pp. 69–77, 2013.
- [19] T. Schaefers, S. Ruffer, and E. Bohm, "Outcome-based contracting from the customers' perspective: a means-end chain analytical exploration," *Industrial Marketing Management*, <https://doi.org/10.1016/j.indmarman.2020.06.002>, 2020.
- [20] R. Nunkoo and H. Ramkissoon, "Small island urban tourism: a residents' perspective," *Current Issues in Tourism*, vol. 13, no. 1, pp. 37–60, 2010.
- [21] M. A. Goldenberg, D. B. Klenosky, J. T. O'Leary, and T. J. Templin, "A means-end investigation of ropes course experiences," *Journal of Leisure Research*, vol. 32, no. 2, pp. 208–224, 2000.
- [22] M. Huber and M. Kleinaltenkamp, "A typology of business usage center members," *Industrial Marketing Management*, vol. 85, pp. 21–31, 2020.
- [23] E. K. Macdonald, M. Kleinaltenkamp, and H. N. Wilson, "How business customers judge solutions: solution quality and value in use," *Journal of Marketing*, vol. 80, no. 3, pp. 96–120, 2016.
- [24] T. J. Reynolds and J. Gutman, "Laddering theory, method, analysis and interpretation," *Journal of Advertising Research*, vol. 28, no. 1, pp. 40–79, 2001.
- [25] J. Gutman and G. Miaoulis, "Communicating a quality position in service delivery: an application in higher education," *Managing Service Quality: An International Journal*, vol. 13, no. 2, pp. 105–111, 2003.
- [26] J. P. Peter and J. C. Olson, *Consumer Behavior and Marketing Strategy*, Irwin Publishing, Chicago, IL, USA, 2009.
- [27] H. H. Kassarian, "Content analysis in consumer research," *Journal of Consumer Research*, vol. 4, no. 1, pp. 8–18, 1977.
- [28] C. Kahraman, T. Ertay, and G. Büyüközkan, "A fuzzy optimization model for QFD planning process using analytic network approach," *European Journal of Operational Research*, vol. 171, no. 2, pp. 390–411, 2006.
- [29] T. L. Saaty, *The Analytic Hierarchy Process*, McGraw-Hill, New York City, NY, USA, 1980.
- [30] S. H. Chen and C. H. Hsieh, "Representation, ranking, distance, and similarity of L-R type fuzzy number and application," *Australian Journal of Intelligent Processing System*, vol. 6, no. 4, pp. 217–229, 2000.
- [31] C. E. Gengler and S. J. Reynolds, "Consumer understanding and advertising strategy: analysis and strategic translation of laddering data," *Journal of Advertising Research*, vol. 35, no. 4, pp. 19–33, 1995.