An Integrated Approach For Developing Environmental Performance Evaluation Of Taiwan's Food Industry

Anirut Pipatprapa, Hsiang-Hsi Huang, Ching-Hsu Huang

Abstract: Environmental performance (EP) is a comprehensive sustainable development concept. Thus, determining the suitable EP indicator is an important process. This study combines structural equation modeling (SEM) and fuzzy analytic hierarchy process (FAHP) to identify the priority weight of factors for assessing the EP of Taiwan's food industry. A SEM approach was used to develop and define EP factors and sub-factors using a questionnaire designed to gather data from 163 managers in the food industry. A FAHP approach was employed to prioritize the scores using a questionnaire to interview 21 experts regarding the different aspects of EP. The SEM results indicate that market orientation (MO), quality management (QM), and innovation capability (IC) have a positive and significant effect on EP. The FAHP results illustrate that quality policy, quality assurance, competitor orientation, and quality control are most important in assessing EP. The findings of this study provide alternative ways to assess EP in the food industry, and assist manager decision-making to reduce the environmental effects of the industry.

Keywords: environmental performance, market orientation, quality management, innovation capability, structural equation modeling, fuzzy analytic hierarchy process, environmental assessment.

1 Introduction

Many firms are inevitably subject to environmental concerns from the public sector and increasing global market pressure regarding environmental protection. Taiwan's food industry plays a significant role in the economy, which increases with the country's economic situation [1]. Taiwan's food industry continues to expand every year. According to the Department of the Ministry of Economic Affairs of Taiwan, Taiwan's food industry in 2014 increased 61 percent from 2013 [2]. Unfortunately, environmental protection was not a priority during this period. The Climate Change Action Network Europe illustrated that Taiwan's climate change performance was 45.45 percent and the country was ranked 52nd out of the 61 countries assessed, as categorized by emissions value, development of emissions, renewable energies, efficiency, and environmental policy [3]. Consequently, Taiwan's government has been galvanized to tackle the environmental problems by establishing environmental regulation and providing an annual budget to support environmental protection throughout the entire food industry processes and business activities.

- *Anirut Pipatprapa is a Ph.D. Student in the Department of Tropical Agriculture and International Cooperation, National Pingtung University of Science and Technology, No.1 Hseuh-Fu Road, Nei-Fu, Pingtung 912, Taiwan; anirut87@hotmail.com*
- *Hsiang-Hsi Huang is Professor in Department of Industrial Management, National Pingtung University of Science and Technology, No.1 Hseuh-Fu Road, Nei-Fu, Pingtung 912, Taiwan; hhuang@mail.npust.edu.tw (Correspondence)*
- *Ching-Hsu Huang is a Professor in the Department of Hotel and Restaurant Management, National Pingtung University of Science and Technology, No.1 Hseuh-Fu Road, Nei-Fu, Pingtung 912, Taiwan; chinghsu@mail.npust.edu.tw*

Moreover, the government has also allocated resources for training, such as on management systems suitable for the food industry, auditing, and assessing environmental effectiveness [4]. The effectiveness of environmental performance (EP) evaluation is essential in assuring that environmental protection adequately meets customer requirements and environmental regulations. Therefore, we aim to determine to what extent MO, QM, and IC affect EP and enhance the efficiency of EP evaluation, this study integrates structural equation modeling (SEM) into a fuzzy analytic hierarchy process (FAHP) to determine the efficiency of the EP evaluation of Taiwan's food industry. We first identify and confirm the factors and sub-factors affecting EP using a SEM approach. Subsequently, a FAHP approach is employed to prioritize various decision elements by assessing experts and specialists from Taiwan's food industry. The results of this process can support a manager's judgment and decrease the ambiguity and subjective error in EP evaluation. The remainder of this study is organized as follows. Section 2 provides a literature review concerning SEM and the FAHP. Section 3 explains the research methodology and combination of the processes. Section 4 presents the results of the SEM and FAHP analysis. Finally, Section 5 details the conclusion in which we summarize the main findings and research contributions.

2 Literature Review

The issues created by the vague and complicated nature of EP assessment, especially in the food industry due to its multi-criteria decision method, can be resolved by combining SEM and the FAHP approach, as done in this study. We explain this approach in this section.

2.1 SEM Approach

SEM is a statistical technique widely used in sociology, business, and management. Moreover, it can test whether a model suits and conforms to empirical data adequately by combining qualitative and quantitative data to estimate causal relationships among variables [5]. The rationale for applying SEM to determine factors and sub-factors that affect EP as follows: (1) SEM does not limit the number of variables and complex relationships of variables concurrently. Furthermore, SEM can measure the relationship between variables from literature or those without theoretical support; (2) SEM can appraise multiple equations, whereas, other techniques, such as the general linear regression, can only estimate one equation; (3) SEM can easily test hypotheses; and, (4) SEM can test reliability and validity through a measurement model assessment [6,7]. The SEM approach has been used for environmental studies. For example, Phan and Baird [8] used SEM to test the impact of environmental management systems comprehensiveness on EP, Lisi [9] employed SEM to investigate the role of EP measurement systems in translating companies' environmental motivations into performance, Chen*, et al.* [10] tested the influence of market orientation (MO), environmental strategy, employee's environmental involvement, and environmental product quality on EP by using SEM analysis, and Gotschol*, et al.* [11] established a model to evaluate the effect of green supply chain management and green production on EP and economic performance using analytic data by the SEM approach. Thus, we propose a model to test the relationship effects of MO, quality management (QM), and innovation capability (IC) on the EP of Taiwan's food industry using SEM analysis, and we identify the proper factors and sub-factors for constructing a FAHP instrument.

2.2 FAHP Approach

FAHP is a decision making technique widely applied to various multi-criteria decision making (MDCM) problems. The FAHP of Chang [12] is employed in this study, which introduced and exceeds the extent analysis method for synthesizing the values of pairwise comparisons. Moreover, the FAHP also eliminates some of the shortcomings of MDCM methods as follows. 1) FAHP uses triangular fuzzy numbers, instead of crisp decision values, of AHP which is easier for the decision maker to employ, calculate, and formulate decisions; and 2) FAHP creates a proper and precise scale of judgment that increases the efficiency of decision making since human assessments are always subjective and imprecise [13,14]. In existing literature, the FAHP approach has been used to solve complicated EP problems. For example, Omidvari and Ghandehari [15] used the FAHP to provide a proper framework for EP assessment in urban management and assist in selecting appropriate choice of weights and Shen*, et al.* [16] developed a model for evaluating a green supplier's performance in a green supply chain using the FAHP approach. Therefore, we adopted the FAHP to assign weights and ranks between various decision elements that effect EP.

3 RESEARCH METHODOLOGY

3.1 Identification Factors and Sub-Factors

Based on previous literature and research, this study is the first study to attempt to integrate the concept of MO, QM, and IC to develop an EP evaluation model, we first identified three important aspects that effect EP: MO, QM, and IC. Furthermore, each factor has a set of sub-factors. The definitions of the factors and sub-factors are explained as follows. MO is the combination of a customer focus and organization culture to create superior products for buyers with superior orientation performance. Moreover, it also integrates customer and competitor information into business strategies and processes. The MO concept of Narver and Slater [17] is adopted for this study. As such, MO is comprised of three sub-factors, which are: (1) customer orientation has a firm emphasis concerning customers' current and future needs by using customer relationship management to assess data and manage customer relationships; (2) competitor orientation refers to understanding competitors' present and future situations to enhance a firm's competitive advantage, such as product and service development, and solutions to meet customer needs and expectations; and, (3) inter-functional orientation describes how a firm's functions and departments cooperate to achieve the organizational goal of satisfying customers. QM is a part of elaborate management systems that can be applied by organizations to enhance and achieve quality objectives and prevent environmental effects. The QM concept for the food industry of Luning and Marcelis [18] is adopted for this study. The five sub-factors of QM are as follows: (1) quality assurance implies planning and systematic activities that are devoted to the quality of food products and services and the prevention of food safety hazards; (2) quality improvement is a fundamental element of QM to develop firms and organizations through cooperation to diagnose problems, identify causes, and establish appropriate remedies; (3) quality design is the process of developing products and services that are suited to meet market and customer needs and wants; (4) quality control is a procedure and activity to control variation in the production process by comparing actual performance with performance goals or standards, and taking action on the difference; and, (5) quality policy handles the overall intentions and organizational goals related to quality environmental protection, food laws and regulations, and commitment to customer needs and expectations. IC is an organization's ability to develop and generate new products through systematic management procedures and knowledge transformation to achieve superior technology and goals [19]. Furthermore, IC also includes the assimilation or exploitation of products and processes to reduce environmental impacts. IC can be classified in to three sub-factors, as follows: (1) process innovation refers to the processes and activities conducted to improve and create the method of production, increase production process efficiency, and decrease negative environmental impacts; (2) knowledge and competency implies the organizational development for creating new ideas, improving production processes, and increasing innovativeness by adapting a knowledge and competency based management system; and, (3) organizational support deals with a firm's strategy, managerial regulation, systems, and methods focused on developing innovativeness in an organization through reward systems and the allocation of resources and facilities. We designed an elaborate questionnaire to determine the effect of MO, QM, and IC on EP. All the questions were applied from published literature, which related to evaluate EP. A seven-point Likert's scale was used to measure the questions (ranking from 1= "strongly disagree" to 7="strongly agree"). Data was collected through multiple techniques, such as a mail survey, an internet survey, and a self-administered survey. Of the more than 300 respondents, consisting of presidents and managers from Taiwan's food industry, 163 answered the questions completely. Thus, the response rate was 54.33 percent, which is acceptable. The confirmatory factor analysis method was utilized to evaluate the measurement model. The results in Table 1 detail the factor loading, Cronbach's alpha, average variance extracted (AVE), and composite reliability (CR) of the constructs. The acceptable values for assessing the measurement model are: (1) the factor loading to test convergent validity should exceed 0.5; (2) the internal reliability should be more than 0.7; (3) the AVE should be higher than 0.5; and, (4) the CR should exceed 0.7. Our proposed model indicates that all the factors are within these acceptable ranges, showing that the measurement model has suitable reliability and good construct validity [5].

TABLE 1
MEASUREMENT MODEL TESTING RESULTS

Construct	Measurement Items	Standard Estimates	Cronbach's Alpha	AVE	CR
Quality management	Quality assurance	0.848	0.839	0.611	0.885
	Quality improvement	0.831	0.809		
	Quality design	0.557	0.762		
	Quality control	0.778	0.805		
	Quality policy	0.853	0.798		
Market orientation	Customer orientation	0.827	0.829	0.687	0.726
	Competitor orientation	0.833	0.829		
	Inter functional orientation	0.827	0.778		
Innovation capability	Process innovation	0.812	0.945	0.606	0.822
	Knowledge and competency	0.766	0.875		
	Organizational support	0.756	0.937		

Subsequently, SEM was used to evaluate the structural model fit by creating links between the latent variables. The hierarchy structure of the EP model is shown in Figure 1. The proposed model was developed by using the three aspects that comprise MO, QM, and IC. The acceptable standards for assessing model fit were as follows: (1) χ^2/df < 2.0; (2) Goodness-of-fit index (GFI) > 0.95; (3) adjusted goodness-of-fit index (AGFI) > 0.80; (4) comparative fit index (CFI) > 0.90; (5) increment fit index (IFI) > 0.90; and (6) root mean square error of approximation (RMSEA) < 0.10 [20].

3.2 FAHP Process

The second questionnaire was designed to gather data from 21 experts from Taiwan's food industry (i.e., food industry managers and academic scholars). A nine-point scale of fuzzy number was employed to compare the factors and sub-factors (ranking from 1="equally important" to 9="extremely important"). Interpersonal interviews were conducted with the experts to determine the elements at each level. Subsequently, the experts answered pair wise comparison questions. A fuzzy comparison matrix was adopted to generate the local weights and global weights of the factors and sub factors, and then the data was normalized by multiplying the criteria factor's weight and sub-factor's weight. For the consistency ratio (CoR) evaluation, we calculated the CoR from the data that was then converted to a fuzzy pair wise comparison matrix. The acceptable standard value should not exceed 0.1 [14].

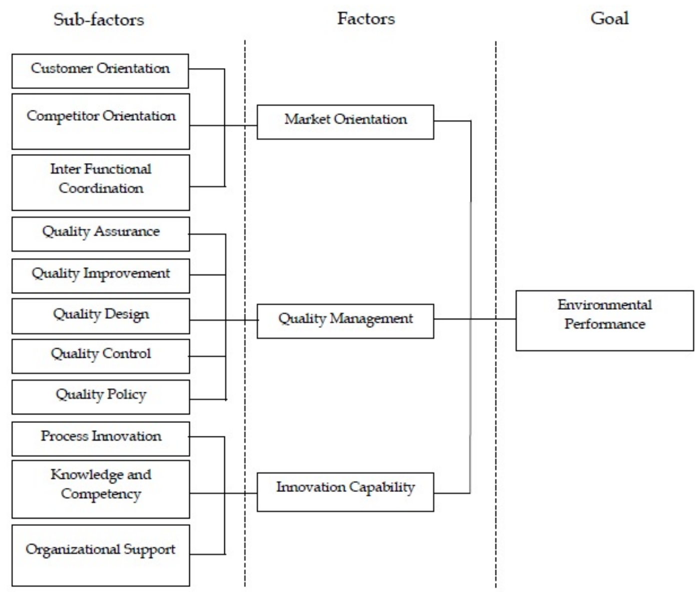

Fig. 1. *Hierarchy structure of environmental performance model*

4 Results

4.1 SEM Results

Figure 2 represents the SEM analytical results used to test the effect of MO, QM, and IC on EP. As illustrated, the results indicate that the proposed model has an acceptable goodness of fit where χ^2/df = 1.349, GFI) > 0.96, AGFI = 0.923, CFI = 0.99, IFI = 0.99, and RMSEA = 0.023. MO, QM, and IC all have positive and significant effects on EP, where (β =0.511, ρ < 0.001), (β =0.594, ρ < 0.001), and (β =0.761, ρ < 0.001), respectively.

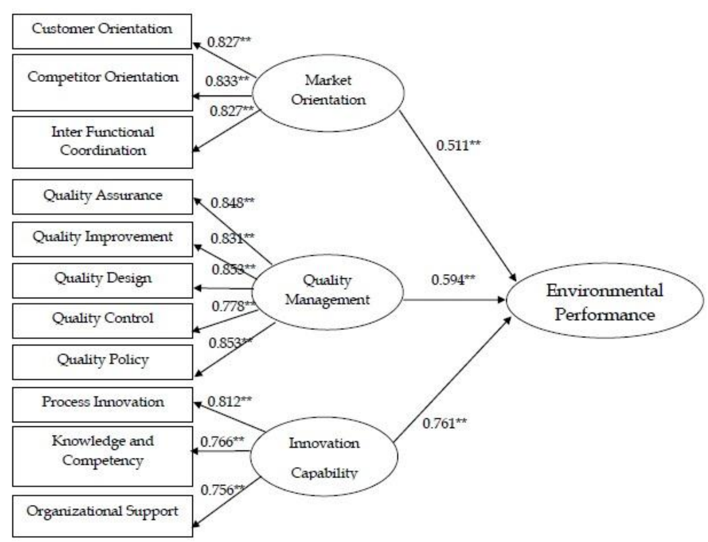

Fig. 2. *Structural equation modeling results.*

4.2 FAHP Results

The FAHP priority weight results and consistency ratios are provided in Table 2. The results show that the global weight values of quality policy, quality assurance, and quality control are the most important aspects for QM. For MO, the experts emphasized competitor orientation followed by customer orientation and inter-functional coordination. Regarding IC, the most important factors are process innovation, followed by knowledge and competency and organizational support. The CoR values of the defuzzification matrix were less than 0.10, indicating that the judgments are trustworthy.

TABLE 2

THE WEIGHTS FOR FACTORS AND SUB FACTOR, CONSISTENCY INDEX, AND CONSISTENCY RATIO RESULTS

Criteria Factors (local weights)	Sub factors (local weights)	Global Weights	Ranks	CI	CoR
Quality Management (0.722)	Quality Assurance (0.261)	0.189	2	0.002	0.001
	Quality Improvement (0.117)	0.085	5		
	Quality Design (0.051)	0.036	9		
	Quality Control (0.132)	0.095	4		
	Quality Policy (0.439)	0.317	1		
Market Orientation (0.163)	Customer Orientation (0.261)	0.043	8	0.006	0.010
	Competitor Orientation (0.598)	0.098	3		
	Inter functional coordination (0.141)	0.023	10		
Innovation Capability (0.114)	Process Innovation (0.701)	0.080	6	0.004	0.006
	Knowledge and competency (0.596)	0.068	7		
	Organizational support (0.302)	0.035	9		

5 Conclusion

The rapid increase in public mindfulness of environmental protection, environmental regulation, and global market forces require firms to implement and integrate management systems into their strategy to meet environmental regulations and reduce environmental impacts. EP measures the environmental impact of a firm. Particularly, the products and production of the food industry is directly impacted by environmental effects and climate change while the food industry also creates waste and pollution from their activities and production processes. Therefore, EP is used to assess management systems and strategies concerning environmental protection. Hence, the aim of this study is to investigate and prioritize the factors that affect the EP of Taiwan's food industry. We combined SEM into a FAHP approach to increase the efficiency of EP evaluation and eliminate the uncertainty of a decision maker's subjective judgment. The SEM approach was used to identify factors and sub-factors, and the results confirmed that MO, QM, and IC and their sub-factors have significant effects on EP. Subsequently, FAHP was adopted to prioritize and normalize the factors. The FAHP results indicate that quality policy, quality assurance, and competitor orientation followed by quality control, quality improvement, and process innovation are the most important factors to assess the EP of Taiwan's food industry. This study provides an alternative concept to assess EP. Although our proposed model was developed for and tested in the food industry, it can be modified and applied to any firm in any industry. Moreover, managers can use the results as guidance for improving and developing their products, services, and production processes to meet environmental regulations and customer requirements to ultimately achieve EP.

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