การจัดลำดับความสำคัญของเกณฑ์คุณภาพธุรกิจค้าส่งไทย ด้วยกระบวนการลำดับชั้นเชิงวิเคราะห์แบบฟัซซี

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บทคัดย่อ

การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อจัดลำดับความสำคัญของเกณฑ์คุณภาพธุรกิจค้าส่งไทย เพื่อเป็นมาตรฐานในการพัฒนาธุรกิจค้าส่งไทยในกลุ่มสินค้าอุปโภคบริโภค และสร้างความเข้มแข็งอย่างยั่งยืนให้กับกิจการค้าส่งไทยและสามารถแข่งขันได้ใน AEC โดยนำ Fuzzy AHP ซึ่งเป็นเครื่องมือที่ช่วยในการตัดสินใจแบบหลายหลักเกณฑ์มาใช้กำหนดความสำคัญและจัดลำดับเกณฑ์คุณภาพค้าส่งไทย เพื่อนำความสำคัญของเกณฑ์มาเป็นแนวทางในการส่งเสริมและพัฒนาธุรกิจค้าส่งไทย ผลจากการศึกษาพบว่า เกณฑ์คุณภาพ ประกอบด้วย 1) ภาวะผู้นำ-การรวมกลุ่มและการวางแผนเชิงกลยุทธ์ 2) การมุ่งเน้นลูกค้า-การตลาดและการเชื่อมโยงโซ่อุปทานภายนอก 3) การจัดการสารสนเทศและการวิเคราะห์ข้อมูล 4) การส่งเสริมและพัฒนาทรัพยากรบุคคล 5) การจัดการกระบวนการทางธุรกิจ และโลจิสติกส์ 6) การจัดการร้านค้าและการจัดวางสินค้า7) การอนามัยและความปลอดภัยในสถานประกอบการค้าส่ง สิ่งเหล่านี้นำไปสู่ผลลัพธ์ทางธุรกิจ ผลจากการศึกษาพบว่า ภาวะผู้นำ-การรวมกลุ่มและการวางแผนเชิงกลยุทธ์ มีความสำคัญมากที่สุด

คำสำคัญ : ฟัซซี AHP / ธุรกิจค้าส่งไทย / การตัดสินใจแบบหลายหลักเกณฑ์ / เกณฑ์คุณภาพค้าส่งไทย / ลำดับความสำคัญ

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A Fuzzy AHP Approach to the Determination of Important Weights of Quality Criteria for Thai Wholesale Business

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Abstract

This study aims to identify and rank quality criteria for Thai wholesale business. Quality criteria for Thai wholesale business is pursued to set standards for consumer products and to strengthen sustainable development for local wholesale business encouraging competitiveness among ASEAN Economic Community (AEC). This study employs Fuzzy AHP to analyse multiple criteria decision making to determine the most important weights of quality criteria for wholesale business in Thailand. The importance of the criteria taken as a guideline is to promote and develop the wholesale business in Thailand. The results of the study revealed that the criteria consist of 1) Leadership, clustering and strategic policy 2) Customer relationship and marketing 3) Information, knowledge management and implementation 4) Human resources 5) Business management, logistics and supply chain 6) Shop management and product placement and 7) Safety, risk assessment and environment. These things lead to business results but the most important factors are leadership, clustering and strategic policy.

Keywords : Fuzzy AHP / Thai Wholesale Business / Multi Criteria Decision Making/ Quality Criteria Thai Wholesale Business / Importance Weights

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1. Introduction

Wholesale business is a distribution service, which is significant to the national economy. In addition, the business generates high income and a large number of personnel employment. It directly plays an important role and has a great impact on Thai citizens' standard of living. The wholesale business is one of the economic mechanisms to aid social development. It also determines the living standards of Thai society by acting as a medium to connect and distribute goods from manufacturers to consumers. In order to gain access to ASEAN Economics Community (AEC), the wholesale business has been expanded increasingly due to intense competition from the entry of foreign large capital investment. Accordingly, trading in border areas of Thailand has dramatically increased. Thai entrepreneurs need to develop and adjust themselves to survive in this strong competition and to increase their own competitiveness.

Formerly, there were ambiguities in using different quality criteria to identify the standard of wholesale business in Thailand. The quality criteria were often ambiguous and vague due to the sensitivity in decision making. For that reason this study applies Fuzzy Analytic Hierarchy Process (Fuzzy AHP) to determine the important weight of quality criteria for accurate results. The benefits of this study will enable the Thai Government to assist wholesale business in Thailand in a more apropriate way both in terms of academic and business development.

Fuzzy Analytic Hierarchy Process (Fuzzy AHP) analysis has been widely used to deal with decision making problems involving multiple-criteria evaluation or selection of alternatives [3], which can be both quantitative and qualitative in nature. Fuzzy AHP is a concept based on the Analytic Hierarchy Process developed by Saaty [9] by applying the concept of fuzzy set theory to a pair wise comparison instead of the crisp value in comparison to the number of AHP. Fuzzy AHP can make decisions under uncertainty factor making decisions more efficiently. Kwong and Bai [8] used a fuzzy AHP approach to the determination of importance weights of customer requirements in quality function deployment. Yadav, Shukla and Mishra [10] used a fuzzy AHP approach to prioritize aesthetic attributes of product. Cheng and Mon [11] use algorithm for evaluating weapon systems by Analytical Hierarchy Process (AHP) based on fuzzy scales, which is a multiple criteria decision making approach in a fuzzy environment. These triangular fuzzy numbers are used to build the judgement matrices through the pair-wise comparison. Ayag and Ozdemir [12] applied a fuzzy AHP approach to evaluating machine tool alternatives. Ayag [13] used a fuzzy AHP-based simulation approach to concept evaluation in a NDP environment. Kahraman, Cebeci and Ulukan [2] employed fuzzy AHP to select the best supplier firm providing the most satisfaction for the attribute determined. Quality criteria is a tool to assist the monitoring of different parts of overall system management, process improvement as well as the improvement of business result and its consistency in line with business roadmaps, decision process personnel, performance and business result.

2. Materials and Methods

The fuzzy AHP technique can be viewed as an advanced analytical method developed from the traditional AHP. Generally, it is impossible to reflect the decision maker's uncertain preferences through crisp values. Therefore, Fuzzy AHP is proposed to relieve the uncertainty of AHP method, where the fuzzy comparisons ratios are used [4].

2.1 Fuzzy Set Theory

Fuzzy Sets, a mathematical theory developed by Zadeh [1] are designed to simulate the ambiguity or uncertainty of the cognitiveprocesses of a human. The fuzzy set theory allows the membership functions to operate over the range of real numbers [0, 1]. A fuzzy set is defined by a membership function and all the information about a fuzzy set is described by its membership function. The membership function maps elements (crisp inputs) in the universe of discourse (interval that contains all the possible input values) to elements degrees of membership within a certain interval, which is usually [0, 1]. Then, the degree of membership specifies the extent to which a given element belongs to a set or is related to a concept. The most commonly range used for expressing degree of membership is the unit interval [0, 1]. If the value assigned is 0, the element does not belong to the set (it has no membership). If the value assigned is 1, the element belongs completely to the set (it has no membership). Finally, if the value lies within the interval [0, 1], the element has a certain degree of membership (it belongs partially to the fuzzy set). A fuzzy set, then, contains elements that have difference degree of membership in it. The main characteristic of fuzziness is the grouping of individuals into classes that do not have sharply defined boundaries. A fuzzy number is a special fuzzy set

$$F = \{(x, \mu_F(x)\,,\, x \in R)\} \quad \textbf{(1)}$$

Where x takes it values on the real line, $R: -\infty < x < +\infty$ and $\mu_F(x)$ is a continuous mapping from R to the closed interval [0, 1]. A triangular fuzzy number denoted as $\widetilde{M} = (a, b, c)$, where $a \le b \le c$ has the following triangular type membership function;

$$\mu_F(x) = \begin{cases} 0 & x < a \\ \dfrac{x-a}{b-a} & a \le x \le b \\ \dfrac{c-x}{c-b} & b \le x \le c \\ 0 & x > c \end{cases} \quad \textbf{(2)}$$

Alternatively, by defining the interval of confidence level α, the triangular fuzzy number can be characterized as:

$$\widetilde{M}_\alpha = [a^\alpha, c^\alpha] = [(b-a)\alpha + a, -(c-b)\alpha + c] \;\forall \alpha \in [0,1] \quad \textbf{(3)}$$

In this study, triangular fuzzy numbers, $\tilde{1}$ to $\tilde{9}$, have been used to represent subjective pair wise comparisons of quality criteria of Thai wholesale business. A tilde "~" is placed above a symbol if the symbol represents a fuzzy set. In order to take imprecision of human qualitative assessment into consideration; the five triangular fuzzy numbers are defined with the corresponding membership function as shown in Figure 1 and Table 1.

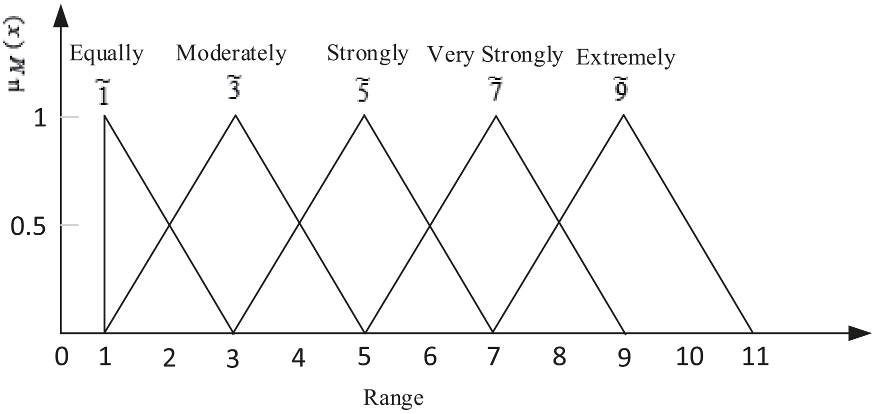

Figure 1 Membership Functions of Triangular Fuzzy Numbers

Table 1 Definition and Membership Function of Fuzzy Numbers [10]

Intensity of Importance	Fuzzy number	Definition	Membership function
1	$\tilde{1}$	Equally important/preferred	(1, 1, 3)
3	$\tilde{3}$	Moderately more important/preferred	(1, 3, 5)
5	$\tilde{5}$	Strongly more important/preferred	(3, 5, 7)
7	$\tilde{7}$	Very strongly more important/preferred	(5, 7, 9)
9	$\tilde{9}$	Extremely more important/preferred	(7, 9, 11)

The $\alpha-$ cut values and index of optimism μ incorporated into Fuzzy AHP matrix take care of the accuracy of the measurement. $\alpha-$cut is known to incorporate the experts or decision maker(s) confidence over his/her preference or the judgments.It will yield an interval set of values form a fuzzy number. For example, $\alpha=$ 0.5 will yield a set $\alpha_{0.5}=$ (2, 3, 4). The operated presented by Figure 2.

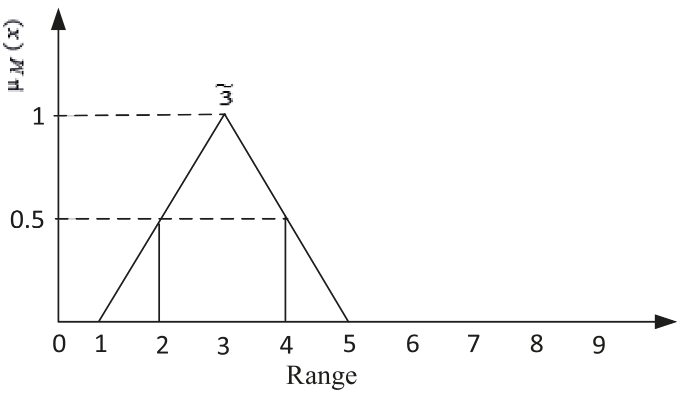

Figure 2 $\alpha-$cut Operation on Triangular Fuzzy Number

Some main operations for positive fuzzy numbers are described by the interval of confidence as give below:

$$\begin{aligned}
&\forall m_L, m_R, n_L, n_R \in R^+, \widetilde{M}_\alpha = [m_L^\alpha, m_R^\alpha], \\
&\widetilde{N}_\alpha = [n_L^\alpha, n_R^\alpha], \alpha \in [0,1] \\
&\widetilde{M} \oplus \widetilde{N} = [m_L^\alpha + n_L^\alpha, m_R^\alpha + n_R^\alpha] \\
&\widetilde{M} \ominus \widetilde{N} = [m_L^\alpha - n_L^\alpha, m_R^\alpha - n_R^\alpha] \\
&\widetilde{M} \otimes \widetilde{N} = [m_L^\alpha n_L^\alpha, m_R^\alpha n_R^\alpha] \\
&\frac{\widetilde{M}}{\widetilde{N}} = [\frac{m_L^\alpha}{n_R^\alpha}, \frac{m_R^\alpha}{n_L^\alpha}]
\end{aligned} \tag{4}$$

where $\widetilde{M}$ and $\widetilde{N}$ are crisp valuesof interval of confidence.

2.2 Computational Procedure of Fuzzy AHP

The AHP method is also known as an eigenvector method. It indicates that the eigenvector corresponding to the largest eigenvalue of the pair wise comparisons matrix provides the relative priorities of the criteria. A vector of weights obtained from the pair wise comparisons matrix reflects the relative performance of the various criteria. The computational procedure of this methodology is summarized as follows:

Step 1: Comparing the performance score. Triangular fuzzy numbers ($\widetilde{1}, \widetilde{3}, \widetilde{5}, \widetilde{7}, \widetilde{9}$) are used to indicate the relative strength of each pair of elements in the same hierarchy.

Step 2: Constructing the fuzzy comparison matrix. By using triangular fuzzy numbers, via pairwise comparison, the fuzzy judgment matrix $\widetilde{A}(a_{ij})$ is constructed as shown below:

$$\widetilde{A} = \begin{bmatrix}
1 & \widetilde{a}_{12} & \widetilde{a}_{13} & \cdots & \widetilde{a}_{1(n-1)} & \widetilde{a}_{1n} \\
\widetilde{a}_{21} & 1 & \widetilde{a}_{23} & \cdots & \widetilde{a}_{2(n-1)} & \widetilde{a}_{2n} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
\vdots & \vdots & \vdots & \cdots & \vdots & \vdots \\
\widetilde{a}_{(n-1)1} & \widetilde{a}_{(n-1)2} & \widetilde{a}_{(n-1)3} & \cdots & 1 & \widetilde{a}_{(n-1)n} \\
\widetilde{a}_{n1} & \widetilde{a}_{n2} & \widetilde{a}_{n3} & \cdots & \widetilde{a}_{n(n-1)} & 1
\end{bmatrix} \tag{5}$$

where

$$a_{ij} = \begin{cases} 1 & ; \ i = j \\ \tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9} \ \ or \ \ \tilde{1}^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}, \tilde{7}^{-1}, \tilde{9}^{-1} & ; \ i \neq j \end{cases}$$

Step 3: Solving fuzzy eigenvalues. A fuzzy eigenvalue, $\tilde{\lambda}$,

is a fuzzy number solution to

$$\tilde{A}\tilde{x} = \tilde{\lambda}\tilde{x} \quad \textbf{(6)}$$

Where $\tilde{A}$ is an $n \times n$ fuzzy matrix containing fuzzy numbers a_{ij} and $\tilde{x}$ is a non-zero $n \times 1$ fuzzy vector containing fuzzy numbers $\tilde{x}_i$.

To perform fuzzy multiplications and additions using the interval arithmetic and $\alpha -$ cut, Equation 6 is equivalent to

$$[a_{i1l}^{\alpha} x_{1l}^{\alpha}, a_{i1u}^{\alpha} x_{1u}^{\alpha}] \oplus \cdots \oplus [a_{inl}^{\alpha} x_{nl}^{\alpha}, a_{inu}^{\alpha} x_{nu}^{\alpha}] = [\lambda x_{il}^{\alpha}, \lambda x_{iu}^{\alpha}]$$

where

$$\tilde{A} = [\tilde{a}_{ij}], \ \tilde{x}^{t} = (\tilde{x}_1, \ldots, \tilde{x}_n), \ \tilde{a}_{ij}^{\alpha} = [a_{ijl}^{\alpha}, a_{iju}^{\alpha}], \ \tilde{x}_i^{\alpha} = [x_{il}^{\alpha}, x_{iu}^{\alpha}], \ \tilde{\lambda}^{\alpha} = [\lambda_l^{\alpha}, \lambda_u^{\alpha}] \quad \textbf{(7)}$$

for $0 < \alpha \leq 1$ and all i, j, where i=1, 2,..., n; j=1, 2,..., n.

Degree of satisfaction for the judgment matrix $\tilde{A}$ is estimated by the index of optimism μ. The larger value of the index μ indicates the higher degree of optimism. The index of optimism is a linear convex combination defined as:

$$\hat{a}_{ij}^{\alpha} = \mu a_{iju}^{\alpha} + (1-\mu) a_{ijl}^{\alpha}, \ \forall \mu \in [0, 1] \quad \textbf{(8)}$$

While α is fixed, the following matrix can be obtained after setting the index of optimism, μ, in order to estimate the degree of satisfaction.

$$\widetilde{A} = \begin{bmatrix} 1 & \hat{a}_{12}^{\alpha} & \cdots & \hat{a}_{1n}^{\alpha} \\ \hat{a}_{21}^{\alpha} & 1 & \cdots & \hat{a}_{2n}^{\alpha} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{a}_{n1}^{\alpha} & \hat{a}_{n2}^{\alpha} & \cdots & 1 \end{bmatrix} \quad (9)$$

The eigenvector is calculated by fixing the μ value and identifying the maximal eigenvalue.

Step 4: Determining the total weights. By synthesizing the priorities over all levels, the overall importance weights of quality management criteria of Thai wholesale business are obtained by varying α value.

The Eigen value method is used for calculating the eigenvector or weighting vector for each pair-wise matrix. The eigenvector is calculated by fixing the μ value and identifying the maximal Eigen value [9]

λ_{max} is calculated then Normalization of both the matrix of paired comparisons and evolution of priority weights (approximate criteria weight). In order to control the results of the method, the consistency ratio for each of the matrices and overall in consistency for the hierarchy are calculated. The deviations from consistency are expressed by the following equation:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (10)$$

Where CI is consistency index.

The consistency ratio *(CR)* is used to estimate directly the consistency of pair wise comparisons.

$$CR = \frac{CI}{RI} \quad (11)$$

Where: RI is selected from Table 2 according to the rank of the matrix.

Table 2 Randomly Generated Consistency Index [4]

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

The acceptable *CR* range varies according to the size of matrix i.e. 0.05 for a 3 by 3 matrix, 0.08 for a 4 by 4 matrix and 0.1 for all larger matrices, $n \geq 5$. If the value of *CR* is equal to, or less than value, it implies that the evaluation within the matrix is acceptable or indicates a good level of consistency in the comparative judgments represented in that matrix. In contrast, if *CR* is more than the acceptable value, inconsistency of judgments within that matrix has occurred and the evaluation process should therefore be reviewed, reconsidered and improved. An acceptable consistency ratio helps to ensure decision-maker reliability in determining the priorities of a set of criteria [4].

2.3 Methodology

The methodology to implement the process is shown in flow chart (Figure 3).

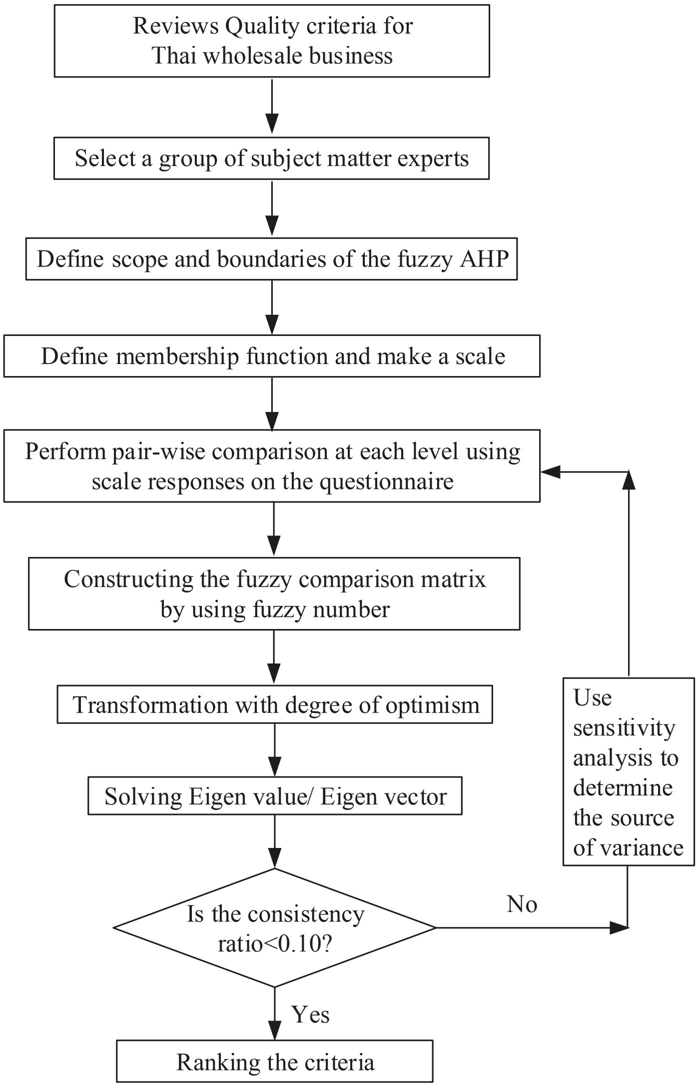

Figure 3 Methodology Flow Chart

Accordingly, it involved literature and quality criteria for Thai wholesale business where it is revised. It is found that business for wholesale consumer products under this study has also opened retail shop. These references are from Krittanathip, Rakkarn, Cha-um and Timyaingam [5] and Krittanathip, Rakkarn, Cha-um and Khamdej [6] and from involved sources. After literature review of the quality criteria for Thai wholesale business is analyzed and synthesized,it indicates three-level hierarchy of Quality criteria for Thai wholesale business (figure 4).

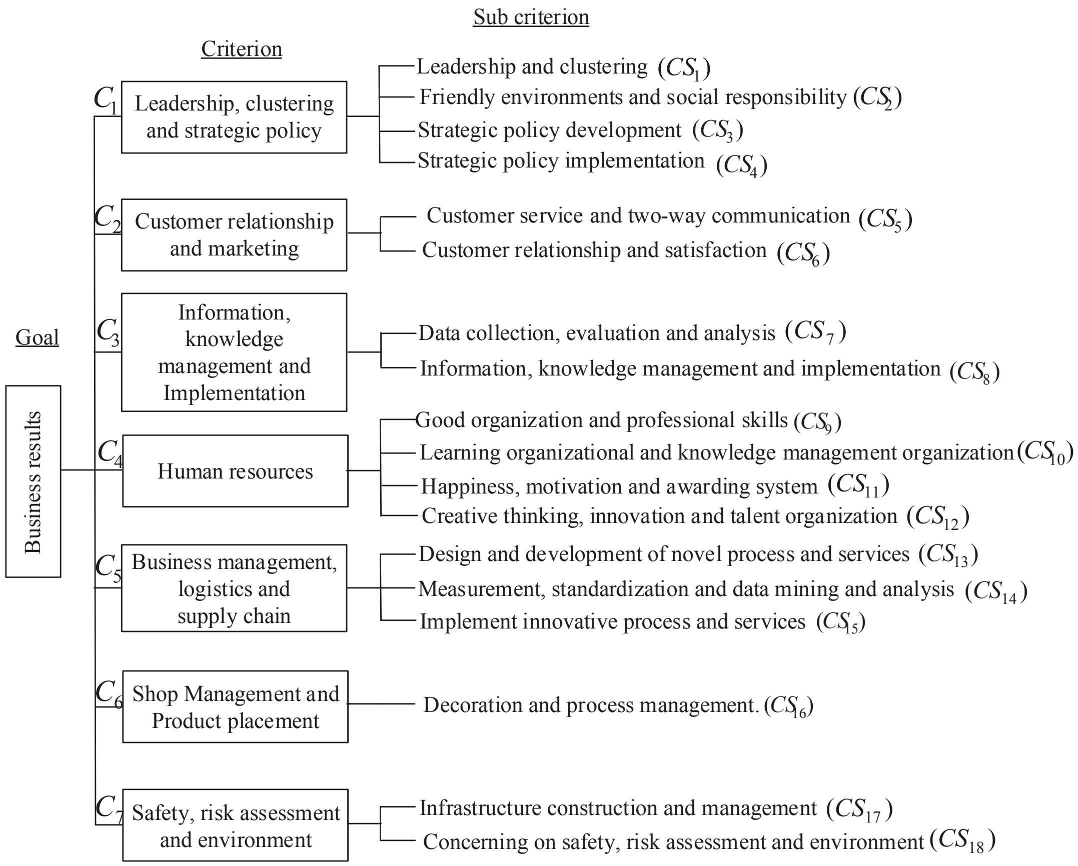

Figure 4 The Hierarchical Structure of Quality Criteria for Thai Wholesale Business

For the selection of interviewees and collection of data,a sample of 35 Thai wholesale entrepreneurs (group 1), who are successful in the Business Development Project initiated by the Ministry of Commerce, 5 representatives (group 2) from the Thai Wholesale and Retail Trade Association and 10 experts in the field of wholesale business are selected.

A fuzzy AHP technique to evaluate the quality criteria for Thai wholesale business has been presented in this study. All criterion of quality criteria for Thai wholesale business have been listed and subsequently, the decision-makers were required to express the preference ($\tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9}$) by pair-wise comparison of the relative importance of each criterion and sub criterion using triangular fuzzy numbers by a separate questionnaire to estimate their relative importance in relation to the element at the proceeding level.

After finalizing the assessment of relation importance of quality criteria for Thai wholesale-retail business, the fuzzy comparison matrixes for each level can be obtained as follows: (FMC: fuzzy comparison matrix)

$$C_1 : FCM_1 = \begin{bmatrix} 1 & \tilde{1} & \tilde{3}^{-1} & \tilde{3}^{-1} \\ \tilde{1}^{-1} & 1 & \tilde{3}^{-1} & \tilde{5}^{-1} \\ \tilde{3} & \tilde{3} & 1 & \tilde{1} \\ \tilde{3} & \tilde{5} & \tilde{1}^{-1} & 1 \end{bmatrix} ; \quad C_2 : FCM_2 = \begin{bmatrix} 1 & \tilde{5}^{-1} \\ \tilde{5} & 1 \end{bmatrix}$$

$$C_3 : FCM_3 = \begin{bmatrix} 1 & \tilde{3} \\ \tilde{3}^{-1} & 1 \end{bmatrix} ; \quad C_4 : FCM_4 = \begin{bmatrix} 1 & \tilde{7} & \tilde{5} & \tilde{3} \\ \tilde{7}^{-1} & 1 & \tilde{3}^{-1} & \tilde{5}^{-1} \\ \tilde{5}^{-1} & \tilde{3} & 1 & \tilde{3}^{-1} \\ \tilde{3}^{-1} & \tilde{5} & \tilde{3} & 1 \end{bmatrix}$$

$$C_5 : FCM_5 = \begin{bmatrix} 1 & \tilde{7}^{-1} & \tilde{5}^{-1} \\ \tilde{7} & 1 & \tilde{1} \\ \tilde{5} & \tilde{1}^{-1} & 1 \end{bmatrix} ; \quad C_7 : FCM_6 = \begin{bmatrix} 1 & \tilde{1} \\ \tilde{1}^{-1} & 1 \end{bmatrix}$$

$$G : FCM_7 = \begin{bmatrix} 1 & \tilde{3} & \tilde{9} & \tilde{3} & \tilde{5} & \tilde{7} & \tilde{9} \\ \tilde{3}^{-1} & 1 & \tilde{7} & \tilde{3} & \tilde{5} & \tilde{5} & \tilde{9} \\ \tilde{9}^{-1} & \tilde{7}^{-1} & 1 & \tilde{7}^{-1} & \tilde{5}^{-1} & \tilde{5}^{-1} & \tilde{3}^{-1} \\ \tilde{3}^{-1} & \tilde{3}^{-1} & \tilde{7} & 1 & \tilde{1} & \tilde{3} & \tilde{5} \\ \tilde{5}^{-1} & \tilde{5}^{-1} & \tilde{5} & \tilde{1}^{-1} & 1 & \tilde{3} & \tilde{3} \\ \tilde{7}^{-1} & \tilde{5}^{-1} & \tilde{5} & \tilde{3}^{-1} & \tilde{3}^{-1} & 1 & \tilde{3} \\ \tilde{9}^{-1} & \tilde{9}^{-1} & \tilde{3} & \tilde{5}^{-1} & \tilde{3}^{-1} & \tilde{3}^{-1} & 1 \end{bmatrix}$$

After finalizing the assessment of relative importance by these experts for the quality criteria for Thai wholesale-retail business, the triangular membership function and α - cuts were used to convert the subject judgments of expert to become fuzzy judgments. Later a degree of optimism for the experts was estimated by the index of optimism μ. All initial individual fuzzy comparison matrices based on triangular membership function and α-cuts were formulated. The lower limit and upper limit of the fuzzy numbers with respect to α are defined using equation 7.

$$\tilde{1}_\alpha = [1, 3-2\alpha], \qquad \tilde{1}_\alpha^{-1} = [\frac{1}{3-2\alpha}, 1],$$

$$\tilde{3}_\alpha = [1+2\alpha, 5-2\alpha], \qquad \tilde{3}_\alpha^{-1} = [\frac{1}{5-2\alpha}, \frac{1}{1+2\alpha}],$$

$$\tilde{5}_\alpha = [3+2\alpha, 7-2\alpha], \qquad \tilde{5}_\alpha^{-1} = [\frac{1}{7-2\alpha}, \frac{1}{3+2\alpha}], \qquad \textbf{(11)}$$

$$\tilde{7}_\alpha = [5+2\alpha, 9-2\alpha], \qquad \tilde{7}_\alpha^{-1} = [\frac{1}{9-2\alpha}, \frac{1}{5+2\alpha}],$$

$$\tilde{9}_\alpha = [7+2\alpha, 11-2\alpha], \qquad \tilde{9}_\alpha^{-1} = [\frac{1}{11-2\alpha}, \frac{1}{7+2\alpha}]$$

Let $\alpha = 0.5$ and $\mu = 0.5$, and substitute above expression into the fuzzy comparison matrices, FCM_1 to FCM_7, all the α - cuts fuzzy comparison matrices can be obtained as follows:

$$C_1 : FCM_1^\alpha = \begin{bmatrix} 1 & [1,2] & [\frac{1}{4},\frac{1}{2}] & [\frac{1}{4},\frac{1}{2}] \\ [\frac{1}{2},1] & 1 & [\frac{1}{4},\frac{1}{2}] & [\frac{1}{6},\frac{1}{4}] \\ [2,4] & [2,4] & 1 & [1,2] \\ [2,4] & [4,6] & [\frac{1}{2},1] & 1 \end{bmatrix} ; C_2 : FCM_2^\alpha = \begin{bmatrix} 1 & [\frac{1}{6},\frac{1}{4}] \\ [4,6] & 1 \end{bmatrix}$$

$$C_3 : FCM_3^\alpha = \begin{bmatrix} 1 & [2,4] \\ [\frac{1}{4},\frac{1}{2}] & 1 \end{bmatrix} ; \quad C_4 : FCM_4^\alpha = \begin{bmatrix} 1 & [6,8] & [4,6] & [2,4] \\ [\frac{1}{8},\frac{1}{6}] & 1 & [\frac{1}{4},\frac{1}{2}] & [\frac{1}{6},\frac{1}{4}] \\ [\frac{1}{6},\frac{1}{4}] & [2,4] & 1 & [\frac{1}{4},\frac{1}{2}] \\ [\frac{1}{4},\frac{1}{2}] & [4,6] & [2,4] & 1 \end{bmatrix}$$

$$C_5 : FCM_5^\alpha = \begin{bmatrix} 1 & [\frac{1}{8},\frac{1}{6}] & [\frac{1}{6},\frac{1}{4}] \\ [6,8] & 1 & [1,2] \\ [4,6] & [\frac{1}{2},1] & 1 \end{bmatrix} ; \quad C_7 : FCM_6^\alpha = \begin{bmatrix} 1 & [1,2] \\ [\frac{1}{2},1] & 1 \end{bmatrix}$$

$$G:FCM_7^{\alpha} = \begin{bmatrix} 1 & [2,4] & [8,10] & [2,4] & [4,6] & [6,8] & [8,10] \\ [\frac{1}{4},\frac{1}{2}] & 1 & [6,8] & [2,4] & [4,6] & [4,6] & [8,10] \\ [\frac{1}{10},\frac{1}{8}] & [\frac{1}{8},\frac{1}{6}] & 1 & [\frac{1}{8},\frac{1}{6}] & [\frac{1}{6},\frac{1}{4}] & [\frac{1}{6},\frac{1}{4}] & [\frac{1}{4},\frac{1}{2}] \\ [\frac{1}{4},\frac{1}{2}] & [\frac{1}{4},\frac{1}{2}] & [6,8] & 1 & [1,2] & [2,4] & [4,6] \\ [\frac{1}{6},\frac{1}{4}] & [\frac{1}{6},\frac{1}{4}] & [4,6] & [\frac{1}{2},1] & 1 & [2,4] & [2,4] \\ [\frac{1}{8},\frac{1}{6}] & [\frac{1}{6},\frac{1}{4}] & [4,6] & [\frac{1}{4},\frac{1}{2}] & [\frac{1}{4},\frac{1}{2}] & 1 & [2,4] \\ [\frac{1}{10},\frac{1}{8}] & [\frac{1}{10},\frac{1}{8}] & [2,4] & [\frac{1}{6},\frac{1}{4}] & [\frac{1}{4},\frac{1}{2}] & [\frac{1}{4},\frac{1}{2}] & 1 \end{bmatrix}$$

Calculate eigenvectors for all comparison matrices from which the importance weights of individual criterion can be obtained. For example, $FCM_1^{0.5}$ can be obtained as shown below after applying Equation 8.

$$C_1 : FCM_1^{0.5} = \begin{bmatrix} 1 & 1.5 & 0.375 & 0.375 \\ 0.75 & 1 & 0.375 & 0.208 \\ 3 & 3 & 1 & 1.5 \\ 3 & 5 & 0.75 & 1 \end{bmatrix}$$

Let $FCM_1^{0.5} = A$. Eigenvalues of the matrix A can be calculated as follows by solving the characteristic equation of A, $\det(A - \lambda I) = 0$

$$\lambda_1 = 4.2336,\ \lambda_2 = -0.0490,\ \lambda_3 = -0.0923 + 0.5534i,\ \lambda_4 = -0.0923 - 0.5534i$$

As the value of λ_1 is the largest, the corresponding eigenvectors of A can be calculated as follows by substituting the λ_1 into the equation, $Ax = \lambda x$

$$x_1 = (0.2391, 0.1780, 0.6920, 0.6575)^T$$

After normalization, the importance weights of the sub criterion CS_1, CS_2, CS_3, and CS_4, can be determined as shown below.

$$C_1 = [W_{CS_1}, W_{CS_2}, W_{CS_3}, W_{CS_4}] = [0.1353, 0.1008, 0.3917, 0.3722]$$

If the consistency ratio ($CR = \frac{CI}{RI}$) is less than 0.1, then comparisons are acceptable; otherwise the opposite is true. If the consistency test is not passed, the original values in the pair wise comparison matrix must be revised by the $CR = \frac{CI}{RI}$ and $CI = \frac{\lambda_{max} - n}{n-1}$

For $\lambda_{max} = 4.2336$, n = 4 in matrix A then $CI = \frac{4.2336-4}{4-1} = 0.0779$

For $RI = 1.32$ (from Table 2) the value of $CR = \frac{CI}{RI} = \frac{0.0779}{0.9} = 0.0866$

For matrix A as, $CR < 0.1$, so this comparison is acceptable.

Following the similar calculation:

$C_2 : FCM_2^{0.5} \begin{bmatrix} 1 & 0.208 \\ 5 & 1 \end{bmatrix}$ by solving the characteristic equation, $\det(A - \lambda I) = 0$; $\lambda_1 = 2.0198$, $\lambda_2 = -0.0198$. As the value of λ_1 is the largest, the corresponding eigenvectors can be calculated as follows by substituting the λ_1 into the equation, $Ax = \lambda x$; $x_2 = (0.1998, 0.9798)^T$. After normalization, the importance weights of the sub criterion, CS_5 and CS_6, can be determined as shown that: $C_2 = [W_{CS_5}, W_{CS_6}] = [0.1694, 0.8306]$

$C_3 : FCM_3^{0.5} = \begin{bmatrix} 1 & 3 \\ 0.375 & 1 \end{bmatrix}$ by solving the characteristic equation, $\det(A - \lambda I) = 0$; $\lambda_1 = 2.0607$, $\lambda_2 = -0.0607$. As the value of λ_1 is the largest, the corresponding eigenvectors can be calculated as follows by substituting the λ_1 into the equation, $Ax = \lambda x$; $x_3 = (0.9428, 0.3333)^T$. The importance weights of the sub criterion, CS_7 and CS_8 after normalization can be determined as shown that: $C_3 = [W_{CS_7}, W_{CS_8}] = [0.7388, 0.2612]$

$C_4 : FCM_4^{0.5} = \begin{bmatrix} 1 & 7 & 5 & 3 \\ 0.146 & 1 & 0.375 & 0.208 \\ 0.208 & 3 & 1 & 0.375 \\ 0.375 & 5 & 3 & 1 \end{bmatrix}$ by solving the characteristic equation,

$\det(A - \lambda I) = 0$; $\lambda_1 = 4.2112$, $\lambda_2 = -0.1678$, $\lambda_3 = -0.0217 + 0.6360i$, $\lambda_4 = -0.0217 - 0.6360i$.

As the value of λ_1 is the largest, the corresponding eigenvectors can be calculated as follows by substituting the λ_1 into the equation, $Ax = \lambda x$; $x_4 = (0.8830, 0.0895, 0.1899, 0.4199)^T$, After normalization, the importance weights of the sub criterio *CS*$_9$, *CS*$_{10}$, *CS*$_{11}$, and *CS*$_{12}$, can be determined as shown that: $C_4 = [W_{CS_9}, W_{CS_{10}}, W_{CS_{11}}, W_{CS_{12}}]$ = [0.5580, 0.0566, 0.1200, 0.2654]

$$C_5 : FCM_5^{0.5} = \begin{bmatrix} 1 & 0.146 & 0.208 \\ 7 & 1 & 1.5 \\ 5 & 0.75 & 1 \end{bmatrix}$$ by solving the characteristic equation,

$\det(A - \lambda I) = 0$; $\lambda_1 = 3.0611$, $\lambda_2 = -0.0611$, $\lambda_3 = 0.00$. As the value of λ_1 is the largest, the corresponding eigenvectors can be calculated as follows by substituting the λ_1 into the equation, $Ax = \lambda x$; $x_5 = (0.1154, 0.8102, 0.5747)^T$, After normalization, the importance weights of the sub criterion, *CS*$_{13}$, *CS*$_{14}$, and *CS*$_{15}$, can be determined as shown that: $C_5 = [W_{CS13}, W_{CS_{14}}, W_{CS_{15}}] = [0.0769, 0.5400, 0.3831]$

$C_7 : FCM_6^{0.5} = \begin{bmatrix} 1 & 1.5 \\ 0.75 & 1 \end{bmatrix}$ by solving the characteristic equation, $\det(A - \lambda I) = 0$; $\lambda_1 = -0.0607$, $\lambda_2 = 2.0607$. As the value of λ_2 is the largest, the corresponding eigenvectors can be calculated as follows by substituting the λ_2 into the equation, $Ax = \lambda x$; $x_6 = (0.3333, 0.9428)^T$, After normalization, the importance weights of the sub criterion, *CS*$_{17}$, and *CS*$_{18}$, can be determined as shown that: $C_7 = [W_{CS17}, W_{CS18}] = [0.2612, 0.7388]$

$$G : FCM_7^{0.5} = \begin{bmatrix} 1 & 3 & 9 & 3 & 5 & 7 & 9 \\ 0.375 & 1 & 7 & 3 & 5 & 5 & 9 \\ 0.113 & 0.146 & 1 & 0.146 & 0.208 & 0.208 & 0.375 \\ 0.375 & 0.375 & 7 & 1 & 1.5 & 3 & 5 \\ 0.208 & 0.208 & 5 & 0.75 & 1 & 3 & 3 \\ 0.146 & 0.208 & 5 & 0.375 & 0.375 & 1 & 3 \\ 0.113 & 0.113 & 3 & 0.208 & 0.375 & 0.375 & 1 \end{bmatrix}$$

by solving the characteristic equation, $\det(A - \lambda I) = 0$; $\lambda_1 = 7.6916$, $\lambda_2 = 0.1242 + 1.7854i$, $\lambda_3 = 0.1242 - 1.7854i$, $\lambda_4 = -0.2979 + 0.7283i$, $\lambda_5 = -0.2979 - 0.7283i$, $\lambda_6 = -0.1722 + 0.1210i$, $\lambda_7 = -0.1722 - 0.1210i$. As the value of λ_1 is the largest, the corresponding eigenvectors can be calculated as follows by substituting the λ_1 into the equation, $Ax = \lambda x$;
$x_5 = (0.7712, 0.5282, 0.0437, 0.2649, 0.1871, 0.1213, 0.0670)^T$, After normalization, the importance weights of the sub criterion, C_1 , C_2 , C_3 , C_4 , C_5 , C_6 and C_7, can be determined as shownthat :
$G = [W_{C_1}, W_{C_2}, W_{C_3}, W_{C_4}, W_{C_5}, W_{C_6}, W_{C_7}]$ = [0.3888, 0.2663, 0.0220, 0.1336, 0.0943, 0.0612, 0.0338]

3. Results and Discussion

The fuzzy AHP approach is a very useful methodology to convert expert's emotion into importance weights of quality criteria. In the pairwise comparisons of AHP, triangular fuzzy numbers were introduced to improve the scaling scheme of Saaty's Method. The central value of a fuzzy number is the corresponding real crisp number. The spread of numbers is the estimation form of the real crisp number. Equation 8 defines how the estimated number, $\hat{a}_{ij}$, reacts to the real crisp number by adjusting the index of optimism, μ. The μ indicates the degree of optimism, could be determined by specialist or Department of Business Development, Ministry of Commerce to apply the findings for the development of wholesale business entrepreneurs. If the real crisp number is overestimated, ($\mu > 0.5$) the value of $\hat{a}_{ij}$ is higher than the central value. If it is underestimated, ($\mu > 0.5$), the value of $\hat{a}_{ij}$ is lower than the central value. In this study setting μ value as 0.5.

The revision of involved literature and interviews of wholesale business entrepreneurs showthat most of the wholesale business in the consumer products have adjusted themselves by offering shop windows to improve sales. The result of using Fuzzy AHP to determine the criteria and importance weights for Quality criteria for Thai wholesale business found that the criteria consist of 1) Leadership, clustering and strategic policy 2) Customer relationship and marketing 3) Information, knowledge management and implementation 4) Human resources 5) Business management, logistics and supply chain 6) Shop management and product placement and 7) Safety, risk assessment and environment, which are consistent with Krittanathip [7]. These factors lead to business results. The most important weight is Leadership, clustering and strategic policy.

In line with this study, to promote and develop Thai wholesale business is to increase more activities and to educate Thai entrepreneurs more on Leadership, clustering and strategic policy. Accordingly, this study also reveals customer relationship, marketing and human resources are of secondary important issues. (See table 3)

Table 3 Importance Weights

Criterion	Importance weight of criterion	sequence of importance	Sub Criterion	Importance weight of sub criterion	sequence of importance
Leadership, clustering and strategic policy	$TW_{C_1} = W_{C_1}$ $= 0.3888$	1	Leadership and clustering	$TW_{CS_1} = W_{C_1} . W_{CS_1}$ $= 0.0526$	6
			Friendly environments and social responsibility	$TW_{CS_2} = W_{C_1} . W_{CS_2}$ $= 0.0392$	9
			Strategic policy development	$TW_{CS_3} = W_{C_1} . W_{CS_3}$ $= 0.1523$	2
			Strategic policy implementation	$TW_{CS_4} = W_{C_1} . W_{CS_4}$ $= 0.1447$	3

Criterion	Importance weight of criterion	sequence of importance	Sub Criterion	Importance weight of sub criterion	sequence of importance
Customer relationship and marketing	$TW_{C_2} = W_{C_2} = 0.2663$	2	Customer service and two-way communication	$TW_{CS_5} = W_{C_2} . W_{CS_5} = 0.0451$	8
			Customer relationship and satisfaction	$TW_{CS_6} = W_{C_2} . W_{CS_6} = 0.2212$	1
Information, knowledge management and Implementation	$TW_{C_3} = W_{C_3} = 0.0220$	7	Data collection, evaluation and analysis	$TW_{CS_7} = W_{C_3} . W_{CS_7} = 0.0163$	13
			Information, knowledge management and Implementation	$TW_{CS_8} = W_{C_3} . W_{CS_8} = 0.0057$	18
Human resources	$TW_{C_4} = W_{C_4} = 0.1336$	3	Good organization and professional skills	$TW_{CS_9} = W_{C_4} . W_{CS_9} = 0.0745$	4
			Learning organizational and knowledge management organization	$TW_{CS_{10}} = W_{C_4} . W_{CS} = 0.0076$	16
			Happiness, motivation and awarding system	$TW_{CS_{11}} = W_{C_4} . W_{CS_1} = 0.0160$	14
			Creative thinking, innovation and talent organization	$TW_{CS_{12}} = W_{C_4} . W_{CS} = 0.0355$	11
Business management, logistics and supply chain	$TW_{C_5} = W_{C_5} = 0.0943$	4	Design and development of novel process and services	$TW_{CS_{13}} = W_{C_5} . W_{CS} = 0.0073$	17
			Measurement, standardization and data mining and analysis	$TW_{CS_{14}} = W_{C_5} . W_{CS_1} = 0.0509$	7
			Implement innovative process and services	$TW_{CS_{15}} = W_{C_5} . W_{CS_1} = 0.0361$	10
Shop Management and Product placement	$TW_{C_6} = W_{C_6} = 0.0612$	5	Decoration and process management.	$TW_{CS_{16}} = TW_{C_6} = 0.0612$	5
Safety, risk assessment and environment	$TW_{C_7} = W_{C_7} = 0.0338$	6	Infrastructure construction and management	$TW_{CS_{17}} = W_{C_7} . W_{CS_1} = 0.0088$	15
			Concerning on safety, risk assessment and environment	$TW_{CS_{18}} = W_{C_7} . W_{CS_1} = 0.0250$	12

4. Conclusions

Fuzzy AHP can be applied to solve the problems on the determination of important weights of quality criteria for Thai wholesale business. However, there are different aspects and levels of comparison of criteria based on the literature and interviews of experts in the field.

Spontaneously over the course of years, the quality criteria is revised with the aims to develop criteria for thewholesale business in terms of sustainable growth and profitability. The limits and obstacles to this study are that the wholesale business are local Thai business,not modern trade and the size is between medium to large. Many of them operate a retail shop. For the small wholesale business, there is a limit on number of personnel, human resource development, marketing and customer's relationship. They also have limited power to negotiate with suppliers where they lack appropriate funding. These issues result in the poor quality of business development.

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