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Article

Two-Stage PLS-SEM and Fuzzy AHP Approach to Investigate Vietnamese SMEs' Export Competitiveness

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Abstract: Vietnam is paying great to the seafood exporting sector, offering various significant production advantages, concluding that it is critical to understand the competitiveness of the target market and implement effective strategies. However, due to COVID 19, the value of Vietnamese pangasius exports resulted in low and unpredictable profits for pangasius farmers. It is obvious to recognize competitiveness as Multi-Criteria Decision Making (MCDM) problem in the uncertain business environment. Therefore, this study is the first to propose a two-staged Partial Least Squares-Structural Equation Modeling (PLS-SEM) and Fuzzy Analytic Hierarchy Process (FAHP) analysis to identify potential criteria and comprehensively investigate the competitiveness of Vietnamese pangasius export Small and Medium-sized Enterprises (SMEs) in the context of China market. First, a dataset of 186 valid respondents from seafood export SMEs was collected through an online survey from June to December 2020. The PLS-SEM approach was applied to ascertain the positive impact of the proposed criteria contributing to the competitiveness of Vietnamese pangasius against China market. The PLS-SEM results showed that all criteria strongly correlated with the pangasius exporting competitiveness. Then, the FAHP method is employed to rank the subjective weights of mentioned criteria based on 12 experts' judgments. Knowledge infrastructure (C3) has the highest rank of competitiveness criteria with the highest weight, followed by Product (C4). In contrast, Prices (C6) was indicated as the lowest rank at 0.107 regarding FAHP results. Furthermore, this study provides insights into stakeholders seeking to improve competitiveness performance.

Keywords: PLS-SEM; FAHP; competitiveness; pangasius; SMEs; MCDM

1 Introduction

Vietnamese pangasius is quite successful in the global market, and it is regarded as the best substitute for white fish scarcity. Pangasius is primarily raised in 10 provinces of Vietnam's Mekong Delta. According to the Vietnam Association of Seafood Exporters and Producers (VASEP), the pangasius export market in Vietnam fluctuates year to year. China continued to be the leading market for Vietnam's pangasius exports in the first 11 months of 2020 [1]. The overall volume of exports in 2019 was USD 662.5 million, up 25.3% from 2018. China provided tax exemptions for imported fisheries in 2019 due to the ongoing US-China trade war. Apart from Vietnam, this nation raised imports from important Asian sources such as India in the previous year. Despite a strong perception of the uncertainties and obstacles with the Chinese sector's prospects, several Vietnamese pangasius exporting companies aggressively encouraged export to this market in 2019. However, due to the COVID-19 pandemic, the number of orders to China decreases significantly [2].

Additionally, Vietnam's pangasius sector competes against a slew of Chinese market players, including India, Indonesia, and Bangladesh. China and India have invested heavily in high technology to raise pangasius actively. Chinese pangasius import standards are identical to those in the United States or the European Union. In the United States, laws have been enacted to ensure food supplies' safety and establish a level of national protection. Some critical laws and regulations pertaining to seafood safety include the Code of Federal Regulations (CFR), the Federal law on food, medicine, and cosmetics, and the Federal law on food, medicine, and cosmetics [3]. The EU ensures that food safety legislation is implemented and that production and commercial enterprises comply with food safety requirements at all production, processing, and distribution stages [4]. Specifically, one of the primary issues confronting the economy of Eurasian Economic Union (EAEU) member states is boosting product competitiveness. This issue has grown especially pertinent in light of growing globalization and inter-country competition [5]. Numerous researches have been conducted on competitiveness and the challenges surrounding it. However, a complete understanding of these definitions and a suitable technique for computing competitiveness indicators have yet to be developed, as competitiveness is a complicated notion that encompasses a large number of considerably distinct objects and elements.

Porter defined a product's, service's, or subject's competitiveness as its capacity to operate on an equal footing with similar goods, services, or competing subjects in market interactions. Competitiveness frequently entails incorporating technological, economic, managerial, marketing, and psychological aspects of the subject and object, depending on the market conditions [6]. Therefore, it is critical to ascertain the factors affecting Vietnam's pangasius export competitiveness to provide solutions to boost competitiveness and assist export for Vietnamese SMEs in addressing immediate market challenges. The study will fill the literature gap by answering the following research questions:

i. *What criteria affect the competitiveness of Vietnamese pangasius export SMEs in the Chinese market?*
ii. *How do the proposed criteria affect the competitiveness of Vietnamese pangasius export SMEs to China market?*

According to the above context, exporting enterprises' competitiveness needs to pay more attention to numerous dimensions, including quality, traceability standards, and food safety requirements. Prior research on competitiveness was reported using linear relations such as Structural Equation Modeling (SEM) approach between variables [7,8]. Additionally, Hair [9] provided an overview of emerging prediction assessment tools for composite-based Partial Least Squares-Structural Equation Modeling (PLS-SEM), notably proposed out-of-sample prediction methodologies. Moreover, the problem's complexity may impair the process's accuracy and effectiveness and the competitiveness and export performance of Vietnamese pangasius exporting enterprises in the setting of the China market. Multicriteria decision-making (MCDM) models can help with these decision-making challenges. Many MCDM methods, such as the Analytical Hierarchical Process (AHP), Analytic Network Process (ANP), Artificial Neural Network (ANN), and others, have been identified and can be used to handle similar decision-making problems [10–12]. Among various MCDM models, the AHP approach is a commonly quantitative approach used to compare pairwise in many fields [13]. To account for the environment's ambiguity and imprecision, numerous researchers have advocated extending MCDM approaches. However, no evidence has been furnished so far of applying the FAHP method in the light of the competitiveness of Vietnamese pangasius exporting enterprises to China market under a fuzzy environment. This fact concludes that there is room for testing the possibilities of a two-staged PLS-SEM and FAHP approach to investigate competitiveness in the pangasius exporting sector. As a result, the following gaps in the existing literature are discussed by some contributions in this article:

(i) *This study is the first to propose a two-stage PLS-SEM and FAHP approach for the field of the competitiveness of Vietnam's pangasius exports to China;*
(ii) *In terms of applications, the proposed approach is applied for a case study in Vietnam to assist stakeholders such as exporters in determining their competitiveness strategies to the China market;*
(iii) *From a larger perspective, this research can help seafood exporting companies or organizations accelerate their business strategy in an unpredictable business environment*.

This study is divided into five sections: Section 2 provides the literature review. Section 3 presents the proposed approach and the dataset that was used. Section 4 examines the competitiveness of Vietnam's pangasius export to China. Finally, Section 5 discusses the conclusion and recommended measures for increasing the competitiveness of Vietnamese pangasius export SMEs in the Chinese market.

2 Literature Review

In the context of Vietnam, pangasius is one of the essential products and is favored by many markets worldwide. Recently, these products were exported to 163 countries, accounting for 95% market share of catfish fillets globally [14]. Each pangasius product has its unique Harmonized System Code (HS), which is used to classify items imported and exported globally. Vietnam exports various pangasius goods, including fillets, frozen pangasius, salted pangasius and dried pangasius, all of which fall under the HS codes 0303, 0304, and 0305. The Vietnam pangasius industry report 2015–2019 indicates that most products supplied to China are classified as HS codes 030462, 030324, and 030493. However, there are approximately 50 things for export from pangasius, but only 6–7 products for the home market [15]. Due to the increased diversity and competitiveness of international markets, policymakers, business managers, and marketing experts have been paying increasing attention to the export performance of the fisheries exporting sector.

Particularly, in terms of policymaking, a better understanding of export performance is crucial as it allows for the accumulation of foreign exchange reserves, increased employment levels, improved productivity, and enhanced prosperity. As a result, studies on the competitiveness of the seafood export business in general and pangasius export, in particular, may be beneficial to both public and private sector officials concerned with the future development and success of exports. Phuong et al. [16] applied the five forces model to analyze factors related to seed production and culture techniques, expansion of export markets, processing infrastructure, and governmental subsidies. Nguyen et al. [17] investigated causal relationships between various variables that represent enablers and outcomes operating within the coffee supply chain to increase the competitiveness of Vietnamese coffee products. The study of [18] conducted an investigation of export performance and competitiveness in the fisheries sector among the Balkan and Eastern European countries. Recently, Ai [19] surveyed 356 leaders and managers of seafood export firms in Vietnam to ascertain the elements affecting their competitiveness.

Eskandari et al. [20] examined factors affecting the food industry's competitiveness using Michael Porter's five-axis competitive forces model, which includes the following: competitive forces among competitors, the power of suppliers of raw materials, the threat of new competitors entering the market, and the potential of alternative products. Rusu et al. [21] determined factors, including GDP, tax, FDI, trade, and cost of chosen countries corporated positively with the nation's competitiveness contributing to the competitiveness of Central and Eastern European countries. Yeganeh [22] empirically studied the influence of cultural and religious elements on national competitiveness. The findings revealed that national competitiveness still has significant consequences even after controlling for socioeconomic development, culture, and religiosity. Little et al. [23] examined the livelihood consequences of four farmed aquatic products: Tilapia, shrimp, freshwater prawns, and pangasius catfish, in four key producing countries: China, Thailand, Vietnam, and Bangladesh. Navghan et al. [24] emphasized the competitiveness of India's seafood trade and its efficiency and relative advantage in the Indian market. Nguyen [25] examined the role of limitations that exist "behind-the-border". Vietnam's technological efficiency and potential exports show much room to grow its rice and coffee exports to its key trade partners.

According to Ketels's analysis [26], the competitiveness pyramid is divided into three components: Input from policymakers (business environment, physical infrastructure, and knowledge infrastructure) and pre-requisites (business performance, productivity, price, cost, and labor supply) contribute to the pyramid's long-term growth. The number of factors in Ireland such as business environment, infrastructure, and labor supply are associated significantly with country competitiveness. However, other factors (productivity, price, and cost) discouraged Ireland's competitiveness compared to other European nations. Although the competitiveness pyramid also proves to be an efficient model to research competition in general and export competitiveness in particular, various factors influencing the competitiveness of pangasius exports have not been analyzed in detail. To be more specific, the original competitiveness pyramid is a necessary but insufficient indicator of pangasius export competitiveness in the case of the China market. As a result, seven potential criteria were proposed, including Business Environment (C1), Physical Infrastructure (C2), Knowledge Infrastructure (C3), Product (C4), Productivity (C5), Prices (C6) and Labor Supply (C7).

As earlier discussions of the competitiveness pyramid and criteria, MCDM procedures such as sampling, prioritizing, ranking, or selecting from a variety of choices are the most commonly used and executed in the case of Vietnamese pangasius export competitiveness. By utilizing a hybrid MCDM method, Enjolras et al. [27] highlighted the strong influence and association between innovation and export activities as critical elements affecting a firm's competitiveness. Vanegas-López et al. [28] applied the AHP-TOPSIS method to identify the international target markets for Antioquia's textile companies. This research indicated that this was the first methodology used for international market selection in the exporting sector in Colombia and Latin America. Peng et al. [29] explored strategies for improving tourism competitiveness using a new DEMATEL-based ANP model in the context of competitiveness in tourism. As demonstrated by [30], subsidies are one of the most significant factors affecting the export performance of Iranian high-technology firms.

Based on a comprehensive review of the methodology, proposed factors related to competitiveness, it is evident that previous researches have been conducted under varying spatial and temporal circumstances. Moreover, several studies directly related to Vietnam pangasius exporting activities in China are relatively modest. In reality, these studies may have several reasons that are inappropriate for studying Vietnamese pangasius exports due to variations in commodities, output conditions, market size. Notably, the previous studies on competitiveness have almost no reports on pangasius exports in general and have overlooked the Chinese sector, one of the largest and most potential import markets of pangasius, for several years.

To the best of our knowledge, many MCDM models have lately been utilized, such as decision support tool; however, it is rarely used in the field of competitiveness in exporting activities. Moreover, the fuzzy set appears to be applicable in determining the structure of decision-makers choices by comparing the overall complexity of commonly used terms for subjective human assessment in the context of exporting competition in the seafood industry. Therefore, this is the first study on these factors that are influencing the competitiveness of Vietnamese export SMEs in exporting pangasius to China using a two-staged PLS-SEM and FAHP approach which combined with a qualitative and quantitative review in order to carry out a thorough, topical, and systematic review of the determinants of pangasius exports in line with the actual conditions of Vietnam regarding China market.

3 Proposed Method

The author proposed a two-stage PLS-SEM and FAHP approach including 2 phases: First, a PLS-SEM analysis was conducted to test and confirm the hypothesis of competitiveness topic. Second, the FAHP approach is used to determine the relative weights of proposed competitiveness criteria based on the experts' opinions.

3.1 PLS-SEM Approach

3.1.1 Collecting Data

The data collecting process was conducted as follows: First, the research survey on ten subjects to assess the understandable and logical level of the questionnaire. After collecting opinions, the authors made appropriate contextual adjustments. The questionnaire design involved the following steps: This study used 5-point Likert scales, moving from "strongly disagree" to "strongly agree", to measure the construct items.

3.1.2 Reliability Test

The reliability analysis results are shown through two indexes: Cronbach's Alpha coefficient is greater than 0.7, and Composite Reliability (CR) is greater than 0.7 [31]. At the same time, the study also evaluates the convergence value of the constructs through the factor loading coefficient greater than 0.5 and the Average Variance Extracted (AVE) greater than 0.5 [31]. Thus, when the constructs achieve convergence and reliability, the analyzes for the constructs by items will be reliable.

3.1.3 Discriminant Validity

In addition to assessing the confidence value and the convergence value, the analysis also requires the constructs to ensure distinctiveness from each other. Two commonly used evaluation methods are: AVE's square root is greater than the corresponding correlation coefficient between the two constructs, and Heterotrait-Monotrait Ratio (HTMT) is less than 0.85 [31].

3.2 FAHP Approach

To achieve tractability, resilience, and low-cost solutions, fuzzy set theory has emerged as the critical method for dealing with imprecision or vagueness in real-world issues. The fuzzy triangular numbers (TFN) can be described as (l, m, u), indicating the least likely (l), most promising (m), and largest conceivable (u) values in TFN. TFN can be defined as follows:

$$\left(\frac{a}{\tilde{M}}\right) = \begin{cases} 0, & if\ a < m, \\ \frac{a-l}{m-l} & if\ l \le a \le m, \\ \frac{u-a}{u-m} & if\ m \le a \le u, \\ 0, & if\ a > u, \end{cases} \tag{1}$$

$$\tilde{M} = \left(M^{o(y)}, M^{i(y)}\right) = \left[l + (m-l)\,y, u + (m-u)\,y\right], y \in [0,1] \tag{2}$$

where $o(y)$ and $i(y)$ denote the left and right sides, respectively, of a fuzzy number. The following illustrates fundamental computations involving two positive TFN, (l_1, m_1, u_1) and (l_2, m_2, u).

$$(l_1, m_1, u_1) + (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2)\,,$$

$$((l_1, m_1, u_1)) - (l_2, m_2, u_2) = (l_1 - l_2, m_1 - m_2, u_1 - u)$$

$$((l_1, m_1, u_1)) \times (l_2, m_2, u_2) = (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2)$$

$$\frac{(l_1, m_1, u_1)}{(l_2, m_2, u_2)} = (l_1/l_2, m_1/m_2, u_1/u_2) \tag{3}$$

Numerous variants of the FAHP have been proposed [32,33]. The weights assigned to the proposed criteria in this study were determined using the FAHP method, which Chang introduced in 1996.

The FAHP process is given below:

Step 1: A hierarchy was built to simplify a complex situation of Vietnamese pangasius export competitiveness criteria to China market.

Step 2: Using the membership function of the linguistic scale (Tab. 1), a comparison matrix was generated. Eq. (4) defines the pairwise comparison matrix below:

$$Z = \begin{bmatrix} (1,1,1) & l_{21}m_{21}u_{21} & \cdots & l_{1n}m_{1n}u_{1n} \\ l_{21}m_{21}u_{21} & (1,1,1) & \cdots & l_{2n}m_{2n}u_{2n} \\ \vdots & \vdots & & \vdots \\ l_{n1}m_{n1}u_{n1} & l_{n2}m_{n2}u_{n2} & & (1,1,1) \end{bmatrix} \tag{4}$$

Table 1: Proposed membership function of linguistic scale

Fuzzy number	Linguistic terms	Fuzzy scales
9	Perfect	(8,9,10)
8	Absolute	(7,8,9)
7	Very Good	(6,7,8)
6	Fairly Good	(5,6,7)
5	Good	(4,5,6)
4	Preferable	(3,4,5)
3	Not Bad	(2,3,4)
2	Weak Advantage	(1,2,3)
1	Equal	(1,1,1)

Moreover $X = (x_1, x_2, \ldots, x_n))$ was the decision set, and $T = (t_1, t_2, \ldots t_n)$ was the target of the matrix.

$$M_{gi}^1, M_{g2}^2, \ldots, M_{g3}^m, i = 1, 2, \ldots, n \tag{5}$$

The aggregated fuzzy values can be calculated in several ways, for example, Eqs. (6) and (7). In this study, geometric mean operations are applied to aggregate group decisions as following Eq. (7):

$$l_{ij} = \min\left(l_{ijk}\right), m_{ij} = \left(\prod_{k=1}^{K} m_{ijk}\right)^{1/K}, u_{ij} = \max\left(u_{ijk}\right) \tag{6}$$

$$l_{ij} = \left(\prod_{k=1}^{K} l_{ijk}\right)^{1/K}, m_{ij} = \left(\prod_{k=1}^{K} m_{ijk}\right)^{1/K}, u_{ij} = \left(\prod_{k=1}^{K} u_{ijk}\right)^{1/K} \tag{7}$$

Step 3: The fuzzy values in the whole target set of each criterion were summed separately, and the $\sum_{i=1}^{m} M_{gi}^{i}$ value was obtained Eq. (8):

$$\sum_{i=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \tag{8}$$

Step 4: Each fuzzy value in the decision set was summed, and $\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}$ was obtained. The inverse vector of $\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}$ was then calculated using Eqs. (9) and (10):

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{i} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right) \tag{9}$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \tag{10}$$

Step 5: Using Eq. (11), the synthetic extent value S_i for each criterion was determined:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} * \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \tag{11}$$

Step 6: The degree of possibility of $M_1\,(l_1, m_1, u_1) \geq M_2(l_2, m_2, u_2)$ was given as Eq. (12).

$$\mathrm{V}(M_1 \geq M_2) =_{x \geq y}^{sup} \left[\min(\mu_{M_1}(x), \mu_{M_2}(y))\right] \tag{12}$$

Eq. (13) was used to calculate the ordinate of the highest intersection point.

$$V\left(M_1 \geq M_2\right) = hgt\left(M_1 \cap M_2\right) = \mu_{M_2}\left(d\right) = \begin{cases} 1 & if\ m_2 \geq m_1 \\ 0 & if\ l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & otherwise \end{cases} \tag{13}$$

Step 7: The degree possibility of a fuzzy convex point being greater than z convex fuzzy points $M_i(i = 1, 2, \ldots, z)$ can be shown by Eq. (14).

$$\begin{aligned} \mathrm{V}(\mathrm{M} \geq M_1, M_2, \ldots, M_z) &= \mathrm{V}[(\mathrm{M} \geq M_1); (\mathrm{M} \geq M_2); \ldots; (\mathrm{M} \geq M_z)] \\ &= min V(M \geq M_\rho), p = 1, 2, \ldots, z \end{aligned} \tag{14}$$

Assuming that z $\neq \rho$ and z = 1,2, ..., and n conditions are fulfilled, Eq. (15) applies:

$$d'\left(A_\rho\right) = \min V\left(S_\rho \geq S_z\right) \tag{15}$$

If A_ρ ($\rho = 1, 2, \ldots, n$) are n elements, then Eq. (16) applies:

$$W = \left(d'\left(A_1\right), d'\left(A_2\right), \ldots, d'\left(A_n\right)\right)^T \tag{16}$$

Step 8: Normalized weight vectors were obtained using Eq. (17):

$$W = \left(d\left(A_1\right), d\left(A_2\right), \ldots, d\left(A_n\right)\right)^T \tag{17}$$

4 A Case Study

Pangasius is one of the top export items of Vietnam in the context of China market. Due to the COVID-19 impacts, depending on the Chinese market, the revenue and profits from pangasius exports of domestic SMEs have declined sharply in recent years. Thus, competitiveness research is critical to enhancing the competitiveness of pangasius exporting firms in Vietnam targeting the Chinese market. The online survey was conducted over six months, from June to December 2020. The author chose to expand the enterprise survey based on VASEP's list of almost 500 seafood exporters. Following the rejection of invalid samples, 186 samples are allowed for analysis. There are 50 respondents from state-owned enterprises in the 186 gathered samples, 133 respondents from private enterprises, and three respondents from foreign-invested enterprises (26.9%, 71.5%, and 1.6%, respectively). The size of the business was classified into two categories: large corporations and SMEs. The total number of businesses accounts for 41.4% and 58.6%, respectively. Otherwise, approximately 32% of responders have less than three years of experience and over 33% work in the quality department.

4.1 PLS-SEM Results

In this study, the PLS-SEM analysis was conducted by SmartPLS software. The model's validity and reliability were evaluated using content, discriminant, and convergent validity measures [31]. The AVE values for the measurement model are provided in Tab. 2, and convergent validity is indicated when the AVE value is more than 0.5 [31].

Table 2 : Reliability analysis

Latent Variable	Cronbach's Alpha	rho_A	Composite Reliability (CR)	Average Variance Extracted (AVE)
C1	0.787	0.792	0.862	0.611
C2	0.819	0.829	0.881	0.65
C3	0.853	0.857	0.911	0.773
C4	0.785	0.801	0.86	0.606
C5	0.83	0.852	0.886	0.659
C6	0.828	0.853	0.896	0.743
C7	0.85	0.854	0.909	0.769
COMP	0.844	0.845	0.906	0.763

As shown in Tab. 3, this study employed Fornell and Larcker's method to determine discriminant validity [34]. When the square root of AVE is greater than the associated correlation coefficient, the variables are discriminating. Bootstrapping is a nonparametric procedure that allows testing the statistical significance of various PLS-SEM results such as path coefficients, Cronbach's alpha, HTMT, and R^2 values. Tab. 2, CR and Cronbach's Alpha values are more significant than 0.7, then the reliability of the measurement model is good. Analyzing the results of the previous tests established that the questionnaire possesses appropriate reliability and validity with 500 bootstrapping iterations [31,34]. The model's discriminant validity can also be determined by examining the Heterotrait-Montrait (HTMT) values proposed by Henseler et al. [35] to ensure the discriminant is accurate. Tab. 4, the HTMTs of this measurement model are all less than 0.502, indicating that the measurement model has good discriminant validity [31].

Table 3: Fornell-Larcker discriminant validity

	C1	C2	C3	C4	C5	C6	C7	COMP
C1	0.782							
C2	0.365	0.806						
C3	0.359	0.311	0.879					
C4	0.369	0.367	0.339	0.779				
C5	0.48	0.319	0.453	0.307	0.812			
C6	0.363	0.301	0.446	0.332	0.433	0.862		
C7	0.219	0.086	0.519	0.219	0.245	0.239	0.877	
COMP	0.537	0.57	0.576	0.482	0.63	0.566	0.37	0.873

Table 4: HTMT discriminant validity

	C1	C2	C3	C4	C5	C6	C7
C1							
C2	0.456						
C3	0.441	0.366					
C4	0.462	0.443	0.397				
C5	0.585	0.362	0.522	0.364			
C6	0.444	0.36	0.533	0.403	0.502		
C7	0.271	0.146	0.606	0.278	0.281	0.284	
COMP	0.659	0.682	0.677	0.579	0.728	0.666	0.434

Cross-validation method to calculate the Q^2 value to evaluate the predictive relevance of the model [31]. Values of Q^2 greater than 0, 0.25, and 0.50 are meaningful and indicate the PLS path model's small, medium, and considerable prediction accuracy in that order. The value of Q^2 for competitiveness obtained using the Blindfolding algorithm is 0.399, indicating a moderate prediction accuracy. Standardized Root Mean Square Residual (SRMR) can be used to measure the model fit of PLS-SEM [31]. The SRMR value obtained at 0.07, which is less than the critical value of 0.08, further shows that this study's overall model has a reasonable degree of adaptation [31], and can explain the influencing factors of export competitiveness. The summarized hypothesis test results are shown in Tab. 5.

Table 5: Hypothesis results

	Original Sample (O)	Standard Deviation	T-statistics	P-values
C5 -> COMP	0.275	0.047	5.880	0.000
C2 -> COMP	0.288	0.058	4.985	0.000
C6 -> COMP	0.192	0.045	4.251	0.000
C3 -> COMP	0.140	0.061	2.294	0.022
C4 -> COMP	0.114	0.055	2.088	0.037
C1 -> COMP	0.114	0.058	1.984	0.047
C7 -> COMP	0.108	0.059	1.829	0.067

4.2 FAHP Results

In the second stage, the FAHP procedure was solved by Excel. A pair-wise comparison matrix of criteria was conducted by a group of 12 experts as decision-makers using linguistic terms (Tab. 1). To demonstrate to calculate the consistency ratio when employing the FAHP model, the following FAHP method includes calculating the seven primary criteria. Tabs. 8–10 illustrates the integrated fuzzy comparison matrix, non-fuzzy matrix for CR, and Normalized matrix for the FAHP model, respectively. Then, the author presents a calculation example of some results in each table-based Eqs. (4)–(6). For example, the author presents how to integrate (C12) values in Tab. 6: $\mathbf{C_{12}(l, m, u)} = (\mathbf{0.502}, \mathbf{0.700}, \mathbf{1.070})$:

$$l_{12} = \left[1^2 * 1^3 * \left(\frac{1}{3}\right)^5 * \left(\frac{1}{4}\right)^2 \right]^{1/12} = 0.502$$

$$m_{12} = \left[2^2 * 1^3 * \left(\frac{1}{2}\right)^5 * \left(\frac{1}{3}\right)^2 \right]^{1/12} = 0.700$$

$$u_{12} = \left[3^2 * 1^3 * 1^5 * \left(\frac{1}{2}\right)^2 \right]^{1/12} = 1.069$$

To calculate the performance rating score's consistency ratio (CR), the linguistic words (triangular fuzzy number) are transformed to a crisp value using the pessimistic (lower bound) and optimistic (upper bound) values of the fuzzy comparison matrix. The non-fuzzy comparison matrix for the primary criteria is shown in Tab. 7.

Table 6 : Integrated fuzzy comparison matrix

	C1	C2	C3	C4	C5	C6	C7
C1	(1, 1, 1)	(0.502, 0.700, 1.070)	(0.717, 1.034, 1.513)	(0.490, 0.677, 1.001)	(0.500, 0.687, 0.931)	(0.490, 0.677, 1.001)	(1.049, 1.528, 2.089)
C2	(0.935, 1.428, 1.991)	(1, 1, 1)	(0.524, 0.734, 1.044)	(0.561, 0.722, 1.000)	(0.882, 1.272, 1.756)	(1.049, 1.528, 2.089)	(1.049, 1.528, 2.089)
C3	(0.661, 0.967, 1.394)	(0.957, 1.361, 1.906)	(1, 1, 1)	(1.211, 1.774, 2.345)	(0.882, 1.272, 1.756)	(1.049, 1.528, 2.089)	(1.049, 1.528, 2.089)
C4	(0.990, 1.477, 2.039)	(1.000, 1.385, 1.782)	(0.426, 0.563, 0.821)	(1, 1, 1)	(0.767, 1.1225 1.565)	(1.049, 1.528,2.089)	(1.049, 1.528, 2.089)
C5	(1.075, 1.457, 2.000)	(0.569, 0.785, 1.133)	(0.569, 0.785, 1.133)	(0.639, 0.890, 1.303)	(1, 1, 1)	(1.049, 1.528, 2.089)	(0.526, 0.734, 1.044)
C6	(0.990, 1.477, 2.039)	(0.478, 0.654, 0.953)	(0.478, 0.6544 0.953)	(0.478, 0.654, 0.953)	(0.478, 0.654, 0.953)	(1, 1, 1)	(0.467, 0.670, 0.985)
C7	(0.478, 0.654, 0.953)	(0.478, 0.654, 0.953)	(0.478, 0.654, 0.953)	(0.477, 0.654, 0.953)	(0.957, 1.361, 1.906)	(1.014, 1.491, 2.139)	(1, 1, 1)

Table 7: Non-fuzzy matrix for CR

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	1.000	0.700	1.034	0.676	0.686	0.676	1.528
C2	1.428	1.000	0.734	0.722	1.272	1.528	1.528
C3	0.967	1.361	1.000	1.774	1.272	1.528	1.528
C4	1.477	1.385	0.563	1.000	1.122	1.528	1.528
C5	1.456	0.785	0.785	0.890	1.000	1.528	0.734
C6	1.477	0.654	0.654	0.654	0.654	1.000	0.670
C7	0.654	0.654	0.654	0.654	1.361	1.491	1.000
SUM	8.460	6.541	5.427	6.372	7.369	9.280	8.517

Table 8: Normalized matrix

	C1	C2	C3	C4	C5	C6	C7	MEAN	WCV	CV
C1	0.118	0.107	0.190	0.106	0.093	0.072	0.179	0.123	0.89	7.208
C2	0.168	0.152	0.135	0.113	0.172	0.164	0.179	0.155	1.119	7.207
C3	0.114	0.208	0.184	0.278	0.172	0.164	0.179	0.186	1.339	7.202
C4	0.174	0.211	0.103	0.156	0.152	0.164	0.179	0.163	1.178	7.212
C5	0.172	0.120	0.144	0.139	0.135	0.164	0.086	0.137	0.991	7.201
C6	0.174	0.100	0.120	0.102	0.088	0.107	0.078	0.110	0.796	7.211
C7	0.077	0.100	0.120	0.102	0.184	0.160	0.117	0.123	0.886	7.188

Table 9: Fuzzy synthetic extent values

	Fuzzy Sum of Each Row			Fuzzy Synthetic Extent Si ($\boldsymbol{l}, \boldsymbol{m}, \boldsymbol{u}$)
C1	4.749	6.303	8.622	(0.067, 0.121, 0.223)
C2	6.000	8.213	10.970	(0.085, 0.158, 0.284)
C3	6.816	9.430	12.580	(0.097, 0.181, 0.326)
C4	6.282	8.604	11.386	(0.089, 0.165, 0.295)
C5	5.425	7.181	9.704	(0.077, 0.138, 0.251)
C6	4.372	5.765	7.838	(0.062, 0.110, 0.203)
C7	4.886	6.470	8.858	(0.069, 0.124, 0.229)
SUM	38.532	51.969	69.961	

Table 10: Weight results

	C1	C2	C3	C4	C5	C6	C7	Degree of Possibility (Mi)	Weight (w)
C1	0	0.790	0.677	0.752	0.896	1.000	0.979	0.677	0.121
C2	1.000	0	0.889	0.963	1.000	1.000	1.000	0.889	0.159
C3	1.000	1.000	0	1.000	1.000	1.000	1.000	1.000	0.179
C4	1.000	1.000	0.926	0	1.000	1.000	1.000	0.926	0.166
C5	1.000	0.893	0.781	0.855	0	1.000	1.000	0.781	0.140
C6	0.929	0.714	0.600	0.675	0.822	0	0.908	0.600	0.107
C7	1.000	0.811	0.699	0.773	0.918	1.000	0	0.699	0.125
SUM								5.573	1.000

To obtain the priority vectors for the FAHP model's criteria, the normalized pairwise comparison matrix is constructed by dividing each column sum by the column sum of each column. The priority vector is then determined by averaging the row elements in the normalized matrix, as shown in Tab. 8. As illustrated in Tabs. 8–10, the CR computations are used to determine the consistency of the pairwise comparison matrix. The following formula is used to get the CR of pairwise comparison matrices.

$$\boldsymbol{C}_{12} = \frac{\boldsymbol{SI}_{C_{12}}}{\boldsymbol{SUM}_{C_2}} = \frac{\mathbf{0.700}}{\mathbf{6.541}} = \mathbf{0.107}$$

$$\boldsymbol{MEAN}_{C_1} = (\mathbf{0.118} + \mathbf{0.107} + \mathbf{0.190} + \mathbf{0.106} + \mathbf{0.093} + \mathbf{0.072} + \mathbf{0.179})\,/\mathbf{7} = \mathbf{0.123}$$

$$\boldsymbol{WSV} = \begin{bmatrix} \mathbf{1.000} & \mathbf{0.700} & \mathbf{1.034} & \mathbf{0.676} & \mathbf{0.686} & \mathbf{0.676} & \mathbf{1.528} \\ \mathbf{1.428} & \mathbf{1.000} & \mathbf{0{,}734} & \mathbf{0.722} & \mathbf{1.272} & \mathbf{1.528} & \mathbf{1.528} \\ \mathbf{0.966} & \mathbf{1.361} & \mathbf{1.000} & \mathbf{1.774} & \mathbf{1.272} & \mathbf{1.528} & \mathbf{1.528} \\ \mathbf{1.477} & \mathbf{1.385} & \mathbf{0.563} & \mathbf{1.000} & \mathbf{1.122} & \mathbf{1.528} & \mathbf{1.528} \\ \mathbf{1.456} & \mathbf{0.785} & \mathbf{0.785} & \mathbf{0.890} & \mathbf{1.000} & \mathbf{1.528} & \mathbf{0.734} \\ \mathbf{1.477} & \mathbf{0.654} & \mathbf{0.654} & \mathbf{0.654} & \mathbf{0.654} & \mathbf{1.000} & \mathbf{0.670} \\ \mathbf{0.654} & \mathbf{0.654} & \mathbf{0.654} & \mathbf{0.654} & \mathbf{1.361} & \mathbf{1.491} & \mathbf{1.000} \end{bmatrix} \times \begin{bmatrix} \mathbf{0.123} \\ \mathbf{0.155} \\ \mathbf{0.186} \\ \mathbf{0.163} \\ \mathbf{0.137} \\ \mathbf{0.110} \\ \mathbf{0.123} \end{bmatrix} = \begin{bmatrix} \mathbf{0.893} \\ \mathbf{1.119} \\ \mathbf{1.339} \\ \mathbf{1.178} \\ \mathbf{0.991} \\ \mathbf{0.796} \\ \mathbf{0.886} \end{bmatrix}$$

$$\boldsymbol{CV} = \begin{bmatrix} \mathbf{0.893} \\ \mathbf{1.119} \\ \mathbf{1.339} \\ \mathbf{1.178} \\ \mathbf{0.991} \\ \mathbf{0.796} \\ \mathbf{0.886} \end{bmatrix} / \begin{bmatrix} \mathbf{0.123} \\ \mathbf{0.155} \\ \mathbf{0.186} \\ \mathbf{0.163} \\ \mathbf{0.137} \\ \mathbf{0.110} \\ \mathbf{0.123} \end{bmatrix} = \begin{bmatrix} \mathbf{7.208} \\ \mathbf{7.207} \\ \mathbf{7.202} \\ \mathbf{7.212} \\ \mathbf{7.201} \\ \mathbf{7.211} \\ \mathbf{7.188} \end{bmatrix}$$

The largest eigenvector (max) is computed in order to obtain the consistency index (CI), the random index (RI), and the consistency ratio (CR):

$$\boldsymbol{\lambda}_{\mathbf{max}} = (\mathbf{7.208} + \mathbf{7.207} + \mathbf{7.202} + \mathbf{7.212} + \mathbf{7.201} + \mathbf{7.211} + \mathbf{7.188})\ /\mathbf{7} = \mathbf{7.204}$$

$$\boldsymbol{CI} = \frac{\boldsymbol{\lambda}_{\mathbf{max}} - \boldsymbol{n}}{\boldsymbol{n} - \mathbf{1}} = \frac{\mathbf{7.204} - \mathbf{7}}{\mathbf{7} - \mathbf{1}} = \mathbf{0.034}$$

with RI = 1.2874 and n = 7, the CR value is calculated as below:

$$\boldsymbol{CR} = \frac{\boldsymbol{CI}}{\boldsymbol{RI}} = \frac{\mathbf{0.034}}{\mathbf{1.287}} = \mathbf{0.027}$$

Consistency ratio CR = 0.027 < 0.1 indicates that the result is satisfactory. The last step was to obtain the synthetic extent value (Si) for each criterion using Eq. (8):

$$\boldsymbol{SUM}_{\boldsymbol{l}_{C_1}} = \boldsymbol{l}_{C_{11}} + \boldsymbol{l}_{C_{12}} + \boldsymbol{l}_{C_{13}} + \boldsymbol{l}_{C_{14}} + \boldsymbol{l}_{C_{15}} + \boldsymbol{l}_{C_{16}} + \boldsymbol{l}_{C_{17}}$$

$$= \mathbf{1} + \mathbf{0.502} + \mathbf{0.717} + \mathbf{0.490} + \mathbf{0.500} + \mathbf{0.490} + \mathbf{1.049}$$

$$= \mathbf{4.749}$$

$$\boldsymbol{SUM}_{\boldsymbol{m}_{C_1}} = \boldsymbol{m}_{C_{11}} + \boldsymbol{m}_{C_{12}} + \boldsymbol{m}_{C_{13}} + \boldsymbol{m}_{C_{14}} + \boldsymbol{m}_{C_{15}} + \boldsymbol{m}_{C_{16}} + \boldsymbol{m}_{C_{17}}$$

$$= \mathbf{1} + \mathbf{0.700} + \mathbf{1.034} + \mathbf{0.676} + \mathbf{0.686} + \mathbf{0.676} + \mathbf{1.528}$$

$$= \mathbf{6.303}$$

$$\boldsymbol{SUM}_{\boldsymbol{u}_{C_1}} = \boldsymbol{u}_{C_{11}} + \boldsymbol{u}_{C_{12}} + \boldsymbol{u}_{C_{13}} + \boldsymbol{u}_{C_{14}} + \boldsymbol{u}_{C_{15}} + \boldsymbol{u}_{C_{16}} + \boldsymbol{u}_{C_{17}}$$

$$= \mathbf{1} + \mathbf{1.069} + \mathbf{1.513} + \mathbf{1.009} + \mathbf{0.930} + \mathbf{1.009} + \mathbf{2.089}$$

$$= \mathbf{8.622}$$

$$\boldsymbol{SUM}_{\boldsymbol{l}} = \boldsymbol{l}_{C_1} + \boldsymbol{l}_{C_2} + \boldsymbol{l}_{C_3} + \boldsymbol{l}_{C_4} + \boldsymbol{l}_{C_5} + \boldsymbol{l}_{C_6} + \boldsymbol{l}_{C_7}$$

$$= \mathbf{4.749} + \mathbf{6.000} + \mathbf{6.816} + \mathbf{6.282} + \mathbf{5.425} + \mathbf{4.372} + \mathbf{4.886}$$

$$= 38.532$$

$$\boldsymbol{C}_1 = \boldsymbol{M}_1\,(\boldsymbol{l}, \boldsymbol{m}, \boldsymbol{u}) = (\mathbf{0.0679{,}0.1213{,}0.2238})$$

$$\boldsymbol{l}_{M_1} = \frac{\boldsymbol{SUM}_{\boldsymbol{l}_{C_1}}}{\boldsymbol{SUM}_{\boldsymbol{u}}} = \frac{\mathbf{4.749}}{\mathbf{69.961}} = \mathbf{0.067}$$

$$\boldsymbol{m_{M_1} = \frac{SUM_{m_{C_1}}}{SUM_m} = \frac{6.303}{51.969} = 0.121}$$
$$\boldsymbol{u_{M_1} = \frac{SUM_{u_{C_1}}}{SUM_l} = \frac{8.622}{38.532} = 0.223}$$

The degree possibility of a fuzzy convex point is calculated by Eq. (11). Normalized weight vectors were obtained by Eq. (14):

$$\boldsymbol{C_{12} = \frac{l_2 - u_1}{(m_1 - u_1) - (m_2 - l_2)} = \frac{0.085 - 0.223}{(0.121 - 0.223) - (0.158 - 0.085)} = 0.790}$$
$$\boldsymbol{C_{21} = 1, (m_2 = 0.580 \geq m_1 = 0.121)}$$

$$\boldsymbol{Min\,(C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}) = 0.677}$$

$$\boldsymbol{w_{M_1} = \frac{0.677}{0.677 + 0.889 + 1.000 + 0.926 + 0.781 + 0.600 + 0.699} = 0.121}$$

As results from Tab. 10, following the weight values, Knowledge infrastructure (C3) has the highest rank of competitiveness criteria with 0.179, followed by Product (C4) with 0.166. In contrast, Prices (C6) has the lowest rank at 0.107.

5 Conclusions

5.1 Conclusions

This study aims to propose a two-staged PLS-SEM and FAHP approach to comprehensively investigate the competitiveness of Vietnamese pangasius export SMEs in the context of China market. After that, the data was then collected and analyzed using both qualitative and quantitative techniques to evaluate how given factors influence the competitiveness of Vietnamese pangasius export SMEs to the Chinese market. Seven proposed criteria were tested and confirmed using the PLS-SEM model. Based on the regression analysis, it is shown that all seven criteria positively correlate with the competitiveness of Vietnam's exporting pangasius SMEs. According to the FAHP approach's findings, the criterion with the most significant influence on the "Competitiveness" of Vietnamese pangasius export SMEs in the China market is Knowledge infrastructure (C3). Price (C6) has the most negligible impact on the competitiveness of Vietnamese pangasius exporting enterprises among selected criteria. Given the state of the Vietnamese pangasius industry, which is experiencing declining market share, squeezed profit margins, and increased standards enforcement, the various firms must collaborate to develop a strategy that benefits all. All businesses must adhere to the tenet that unity is necessary for survival. This is critical, as competitors from neighboring countries and other white fish producers in China are vying for market access and a more significant share of the Chinese market.

5.2 Implications

In this study, the practical approach of FAHP based PLS-SEM analysis has been established. Identification of critical criteria through experts' opinions and literature is one of the significant advantages of the present study. Stakeholders such as exporters and policy-makers can utilize the proposed framework to evaluate and determine the competitive criteria for exporting activities. The obtained results can be considered a crucial guideline for the organizations such that it has a better understanding of the Vietnamese product export in general, in the context of China market, in particular. The applied comparative analysis supports decision-makers to test the observation stability and reliability of the proposed model. As a result, the following recommendations are appropriate:

(i) SMEs must seek government assistance to pool their resources and take collective action rather than individual action. This may result in a combination of private sector actors pursuing offensive/proactive strategies and a public voice speaking on behalf of a collective group.

(ii) Industry leaders should convene firms to request joint certification, critical for efficient marketing. Domestic changes will result in more producers and processors being GlobalGAP and ASC certified.

(iii) Processors must be concerned with short-run food safety and hygienic standards and work to minimize or eliminate product refusals. This requires processors to take a proactive/offensive approach to hygienic standards and product refusals. Over time, firms should develop strategies to ensure that standard enforcement benefits their competitive edge by fostering economies of scale and scope in marketing.

(iv) The private sector should take the lead in educating the public about the pangasius industry's importance to the Vietnamese economy. The public sector should assist firms in adapting to the new standards and be willing to form joint representation with pangasius exporters. Approximately 99% of pangasius sold at the moment are frozen fillets. The private sector should take a proactive and offensive stance, seizing opportunities to expand market share in the China market through product diversification.

5.3 Limitations

Since the number of companies exporting pangasius to China is small, the author needed to change observations to collect data from all seafood exporters. What is more, due to the severe situation of the COVID 19 pandemic, which has resulted in many changes, the data for 2020 is still limited and non-specific, so the information in the authors' analysis of factors is not truly objective. Although some information has been updated, it is still not specific and clear. In future studies, researchers should conduct further studies over a long period and with a broader sample size to determine the competitiveness of exporting SMEs. Furthermore, the real-world competitiveness problem should also apply various analytical techniques combining with MCDM models and Spherical Fuzzy Sets [36]- the newest Fuzzy Set developments to provide a more profound understanding of competitiveness.

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