Multi-Costs Evaluation for Logistics Value Chain in Vietnam: A Fuzzy AHP Approach

Thi Thu Ha Do[#1], Van Kien Pham[#2], Na Le[#3]

[#1] *Faculty of Economics, Ho Chi Minh City University of Economics and Finance*
hadtt@uef.edu.vn

[#2] *Science and Technology Department, Ho Chi Minh City University of Economics and Finance*
[2]kienpv@uef.edu.vn (corresponding author)
141 – 145 Dien Bien Phu, Ward 15, Binh Thanh District, Ho Chi Minh City, Vietnam

[#3] *School of Law, University of Economics Ho Chi Minh City*
59C Nguyen Dinh Chieu, Ward 6, District 3, Ho Chi Minh City, Vietnam
[3]nal@ueh.edu.vn

***Abstract*— There is a paradox that Vietnam is becoming the leading country in the Southeast Asia region in terms of low-cost advantages. However, the logistics industry in Vietnam is not in this trend, because its costs are being evaluated as very high compared to other countries. Over the years, there have very few empirical studies focusing on this issue. In addition, the costs of logistics services are very diverse, but there is a lack of studies to assess these costs as a whole.**

Therefore, this paper aims to fill the mentioned research gaps by assessing the existing costs of logistics services in Vietnam. To accomplish this goal, the paper uses the concept of the logistics value chain (LVC) to systematically arrange costs and the Fuzzy-AHP (FAHP) method to measure the extent of the costs arising in the LVC. Based on the existing literature, four main costs and 14 sub-costs are selected to build the research model and questionnaire. A total of 20 experts are invited to participate in a face-to-face interview to evaluate the costs based on the pairwise comparison matrix.

The findings show that costs incurred in the LVC are considered to be high in all four stages, of which procurement costs (C1) and production costs (C2) are the most concerns and need to be handled, while storage costs (C3) and transportation costs (C4) should be gradually improved in order to enhance the competitiveness of the logistics industry in Vietnam.

Overall, the paper has contributed to supplementing the literature in the given field in terms of cost assessment in the LVC. Besides, the findings are also valuable references for managers to cut the logistics costs throughout the LVC.

Keywords*— *Logistics Value Chain, LVC, Costs evaluation, Vietnam, The FAHP

1. Introduction

In Vietnam, the logistics industry is growing and becoming an important link for businesses to gain a competitive advantage and to reduce costs in all fields [1]. According to the Vietnam Logistics Business Association (VLA), logistics services in Vietnam currently have accounted for nearly 20.9% of the country's GDP [2]. Thus, if the country has a comprehensive value chain for the logistics industry, it will contribute more to the country's development [3]. However, at present, the LVC in Vietnam is still relatively weak or quite fragmented [1]. Activities in the LVC such as shipping, consolidation, container handling, transportation, warehousing, distribution centre are not creating strong value for the logistics industry when operating in a fragmented manner and lacking strategies for long-term linkages [4]. The cost of logistics activities in Vietnam is very high compared to other countries in the region and the world. According to report [5], the total logistics cost of Vietnam in 2016 was 41.26 billion USD, equivalent to 20.8% of total GDP, while developed countries recorded only from 9-14%. Therefore, the logistics industry in Vietnam has to do many things to reduce the overall logistics costs.

So, there is a paradox that is happening in the country when the inherent advantages of costs are not happening to the logistics industry. For this reason, accurately assessing and measuring the costs incurred in the LVC play a very important role to aid logistics managers in identifying the primary and secondary costs in their cost-reduction path.

Over time, there have been many different studies focusing on logistics activities [6, 7, 8], or particularly on logistics costs [1, 9, 10, 11].

International Journal of Supply Chain Management
IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

However, these studies analysed costs discretely, so it makes many difficulties in evaluating logistics costs as a whole as there exist numerous types of costs in logistics activities [11, 12, 13]. Therefore, a study on the evaluation of logistics costs based on the concept of LVC seems to be lacking in the given literature. Therefore, this article is done in an attempt to fill the said research gap.

In so doing, this study modelizes the activities that take place in the logistics industry through the value chain concept [14], which includes primary and supporting activities involving many participants such as suppliers, manufacturers, collectors, traders, distributors, retailers, exporters and customers, etc. The costs incurred from these stakeholders' activities are arranged in the hierarchical model based on the AHP theory [15]. This model allows us to arrange costs according to the activities of the LVC, which is set up from left to right, equivalent to level 0 to level 2. In which, level 0 indicates the main goal, while level 1 and level 2 represents the main costs and sun-cost, respectively [15]. Based on this model, the expert questionnaire will be designed to collect the primary data from experts in the given industry. Then, the collected data is processed by the FAHP method. This method is the combination of the fuzzy the AHP theory and has been discussed widely by researches. The reason for the choice of this method is the existence of gaps in the evaluation of industry experts. Fuzzy numbers will help overcome this problem well [16, 17, 18, 19, 20]. Generally, the research provides managers in the logistics industry and policies-makers a valuable reference, thereby they can make a priority in reducing logistics costs. Additionally, this study contributes to improving the competitiveness of the logistics industry in Vietnam.

2. The current state of logistics costs in Vietnam

With a coastline of 3260 km excluding islands, it can be said that this geographical feature of Vietnam is an advantage in developing logistics services, especially sea transport activities, in case of taking this advantage in the right way. Local and international businesses are always more willing to invest in countries that operate logistics services effectively leading to high logistics performance, and minimize total landed costs [1].

However, compared to the average of countries in the Association of Southeast Asian Nations (ASEAN), the logistics costs in Vietnam are believed to still be considerably high because of inefficiencies in the logistics system so that lead to the limited potential in developing its global value chain [12]. According to a report from the World Bank researching about Vietnam trucking sector, the logistics costs of firms in this country are reckoned to be higher than most companies in the same industry in ASEAN nations due to the fact that it occupies approximately 21% of national GDP. This problem causes a surge in the costs of products for manufacturers and customers and also influences the national exporting competency [21].

There is a noticeable signal of Vietnam's logistics capacity in recent years, which is the raise of its logistics performance index (LPI) from 2.98 in 2016 to 3.27 in 2018, reaching the rank of 39 out of 160 countries measured, and ranking 3rd among ASEAN countries, behind only Singapore and Thailand [22]. This shows that Vietnam's logistics costs have somewhat improved. Therefore, in order to maintain this development, it is necessary to have a general assessment of the cost components of total logistics costs so that businesses can focus on developing cost-effective strategies.

3. Literature review

3.1 Logistics value chain (LVC)

3.1.1 The concept of LVC

The value chain, also known as value chain analysis, is a concept in business administration that was first described and generalized by the book [14], of which clearly reckoned a framework representing the full range of activities adding value to a product or service for its customers. As to study [15], the main goal of building a value chain in an enterprise is from the basis of providing more value to customers, competitive advantage will then be built because the more value an organization creates, the higher the profit it gets.

Refer to value chain in the logistics industry, it is understood as the application of value chain analysis in logistics activities which optimize all works happening in the entire supply chain for increasing the value of a product or service, thereby adding more value to the final consumer [23]. Thereby, the concept of the logistics value chain (LVC) is generated and considered to be a part of the enterprise's value chain [24]. In a supply chain, also defined as the logistics network, various types of logistics activities frequently take place for implementing the works related to planning, managing, coordinating and controlling all types of flows between partners in the chain [25, 26].

Through these activities, the value that every logistics activity creates will be determined to illustrate the essence of the supply chain and demonstrates how the supply chain is shaped [24].

3.1.2 Important roles of LVC

To survive sustainably in the market, companies are forced to intensify their competitiveness which is represented through the capability of minimizing probable costs or creating differentiation by attempting higher benefits to the customer for the same cost during the process of supplying goods and services [27]. Besides, the value chain strategy is also claimed as one of the essential ways of developing competitive advantages [28]. Hence, the role of the logistics value chain in a company is to make it impossible for customers to find an alternative elsewhere for such high value-added services while still being offered preferable benefits with the same (or lower) cost [27].

The value chain concept itself concentrates on adding value to partners and processes while the supply chain which is also defined as the logistics network, focuses on cost-minimizing logistics solutions [29]. Correspondingly, the value chain for logistics is built to achieve more added-value derived from the effort of reducing logistics costs from manufacturers, distributors, logistics companies, and consumers [23]. Instead of competing on products' price, many firms choose to serve value-added services together with their logistics activities for differentiating their position from competitors [26].

Moreover, through the logistics value chain, non-value activities will be identified and eliminated, helping businesses make good use of their resources. From there, enterprises may decrease logistics costs as well as raise the effectiveness of their logistics operations [10]. The total cost of logistics has become one of the leading economic supply chain productivity metrics [11].

3.1.3 Participants in LVC

Logistics operations play a vital role in shaping the loops of supply chains and track the flows of materials, information, and cash that are necessary to fulfill the requirements of consumers [11]. A supply chain is an associate network including many stakeholders such as suppliers, manufacturers, collectors, traders, distributors, retailers, exporters and customers, who not only jointly converts a simple commodity into a completed product which would be valued by end customers but also manages returns at every level [10, 30]. The implementation and management of a process aiming to supplement value to a product are the responsibility of every supply chain member [30].

Hence, in order to highly satisfy customers as well as achieve efficiency in business, organizations need to collaborate closely with their logistics partners in the supply chain. Nonetheless, it is difficult to choose an appropriate partner as a strategic alliance in the logistics value chain due to its ambiguity and intricacy. The inability to set reasonable goals or ineffective communication among parties can contribute to daunting problems so selecting the right partner may provide valuable competitive advantages [3].

Due to the multi logistics functions of every partner in the supply chain, each firm could take part of being a supplier when providing supplies, a manufacturer when producing products or services for providing to other stages, a warehouse when storing products for responding the future demands, and a distributor when transporting products to its customers. Therefore, this paper determines the total logistics costs operating in the logistics value chain based on four main logistics roles of a company, including supplier, manufacturer, warehouse and distributor. This order relies on the common stream of the supply chain from upstream to downstream in changing from the materials to finished goods while adding value in it.

(a) Suppliers

One of the first responsibilities that contribute to establishing a supply chain belongs to the suppliers together with the initial logistics work for starting all operations of companies is procurement. Essentially, the procurement happens in every stage of the supply chain in which a final-product manufacturer connects with outsider suppliers for procuring customized specific parts for distinct producing stages [31]. Most businesses choose to use external logistics suppliers for outsourcing and purchasing because this helps them to decrease costs as well as uncertainties and risks in lacking relevant knowledge and skills. Thanks to this, they can focus on enhancing their productivity, services, quality

and sustain their flexibility [32]. Success in competition has a considerable contribution to suppliers because most companies tend to utilize internal competencies for focusing on what they do best. That is why they choose to acquire supplies from external providers for responding to non-core demands.

(b) Manufacturers

The next stage in the supply chain is manufacturers who construct factories to receive materials and provide completed products to the next stages [33]. A manufacturer who positively pursues purchasing and supply base management strategies, together with being steady in providing products at the right time, in the right quantities and in the right quality, could achieve competitive performance benefits more than its rivals [34]. They not only produce physical products but also supply general logistics services. As for manufacturers, new business chances might be pursued owing to applying services to their chain, taking responsibilities of previous customer activities, or creating subsequent value activities [35].

(c) Warehouses

Warehousing is defined as a function in the logistics system which is responsible for storing many types of products at and between two partners in the supply chain [8]. The warehouse would operate effectively when it can provide exactly the location of inventories, supplement value-added services to consumers, be adaptable in interacting with its providers, carry out the consolidation of orders, be flexible in handling variable manufacturing lead time, process the products returned, perform quality checking, and be acumen to market fluctuations [27]. Many value-added services might be provided in the warehouse for boosting the satisfaction of customers, such as repackaging larger shipments into smaller retail quantities, shrink-wrapping shipments, supporting returned products, assembling products, and testing products [8].

(d) Distributors

Distributors are seen as bridges to connect the place of supply and the place of demand in the supply chain [33]. For serving diversified demands of customers over a wider geographic area, distributors, also known as distribution centres, are not only responsible to distribute products to subsequent partners in the supply chain but also operate other activities, such as consolidating shipments to transport more economical in the case of various components of an order are required to deliver to one destination [27]. In order to gain a market share, distributors tend to concentrate on investment in decreasing the transit time for increasing their speed and reliability of service [36]. Shifting flexibly the push and pull boundary, as called the decoupling point, between upstream partners and downstream partners will help distributors to achieve the cost-efficient, increase the quality and effectiveness of the supply chain, and create more value to the flow of logistics activities [37, 38, 29].

3.2 Costs incurred in the LVC

3.2.1 Procurement costs of suppliers (SC1)

According to managers who manage inputs, the meaning of purchasing is greatly limited so the term of procurement refers to the larger range of meanings and more commonly used [40]. Procurement costs generally account for a small proportion of total costs but often have a significant effect on the overall cost and differentiation of the company. Therefore, the capacity to achieve the lowest cost and highest quality of products' components compared to competitors is one of the keys to business success [41]. As to the relationship between a supplier and a firm that demands to buy supplies, this paper defines three cost components of the procurement costs, involving materials costs, purchasing costs, and communication costs.

(a) Material costs (SC11)

In order to operate the procurement activity, the company first needs to analyse the quantity and types of materials for procuring, find proper suppliers and negotiate about terms and conditions, insurance and payment methods, then arranges the delivery in such a way that supports the transfer of materials to the company [33]. All expenses incurred from these activities will be collectively referred to as material costs.

(b) Purchasing costs (SC12)

The purchasing cost is spent on the department which analyses the way that procurement situations affect purchasing processes so that they can understand their resources, routines, and competence [33]. From there, their purchasing

processes would be implemented efficiently [42]. The works are done to operate effectively the purchasing process constitutes the purchasing costs.

(c) Communication costs (SC13)

There are three key flows running in the supply chain which are cash flow, information flow and materials flow [11, 30], of which the communications costs are generated from the run of information flow for coordinating all supply chain stages and pass information related to products and orders among partners [33]. In order to operate this flow, the companies need to pay for activities and tools which support them to communicate with other parties, such as the internet, telephone system, fax and other similar equipment [11, 33].

3.2.2 Production costs of manufacturers (SC2)

For spreading the relevant fixed costs over more units as well as decreasing production cost per item, the manufacturers ordinarily tend to operate their long-term production plans for individual goods [8]. Hence, there are two components, which are separated by this study, contributing to productions costs: ordering costs and manufacturing costs. These costs represent to different activities which directly affect the production process of manufacturers.

(a) Ordering costs (SC21)

In order to make the production process, manufacturers will need to pay for some activities aiming to set up the orders. This expense is called ordering costs which are paid for activities such as forming an inventory control system based on data exchange [43], hiring employees to receive the order through phone or technology tools, managing the credit, verifying the availability of inventory, getting goods when arriving, recording orders into the system, processing invoice, and issuing payments [8].

(b) Manufacturing costs (SC22)

The manufacturing cost of a product is estimated from the early phases of production including designing, modifying, forming the features, to later activities such as materials selecting and processing [44], evaluating and optimising of machine processes [45]. Additionally, manufacturing costs are also impacted by factors of set-up time and operations time which are relevant to the quantity of production affected by economies of scale [27, 46].

3.2.3 Storage costs of warehouses (SC3)

The basic function of the warehouse is storage [27]. However, in order to perform this function completely and effectively, the warehouse will need to operate many other auxiliary activities and incur related costs including inventory carrying costs, stockout costs, damage costs, warehousing costs, and opportunity cost.

(a) Inventory carrying costs (SC31)

Inventory carrying costs are associated with situations such as arranging space for holding goods, dealing with products being shrinkage and obsolescent, preserving and handling products, especially products which require special conditions, and some of the other expenses related to inventory service, insurance, taxes and interest rate [8, 11]. The holding of products during its movements (pipeline inventory) and the keeping of products for facing unexpected demands (safety stock) are also components constituting to the inventory carrying costs [11].

(b) Stockout costs (SC32)

Lessening the level of goods stored in the warehouse might save money for the firm but lead to the situations of a shortage. These kinds of situations depend on the capacity planning of the company in determining the highest volume of products being served to customers at a certain time as well as arranging the available facilities and resources to satisfy the demand [33]. Stockout costs are estimated costs or penalties for shortage conditions which are associated with the reaction of customers if the firm is out of stock in case of products being demanded due to such situations are far more irritating to consumers since they have fewer choices [8].

(c) Damage costs (SC33)

The situations that cause losses in the warehouse that make companies incur relevant costs might be obsolescent goods, goods being lost or misplaced because of wrong professional skills such as heavy lifting or using lighters, or product be pilfered due to negligence in warehouse management process [33]. Besides, using hazardous materials causing products to be broken or damaged, insufficient width for aisles because of cramped space, forklift puncture and movement bottlenecks, catching fire to the warehouse and making employees be injured or

dead could also arise costs from settling relevant damages [8].

(d) Warehousing costs (SC34)

Building and maintaining the warehouse, regrouping products [8, 27], applying computer applications for controlling and monitoring the procedures of a warehouse [47] are activities that constitute the warehousing costs.

(e) Opportunity costs (SC35)

The opportunity cost refers to the right products being excluded and the warehouse location is replaced by the wrong products [8]. Companies storing large quantities of goods just to be in a state of timely response to all types of customer needs will suffer a high opportunity cost [8]. The same thing will also happen with businesses that have invested a large amount of capital in equipment that is not suitable for storage needs.

3.2.4 Transportation costs of distributors (SC4)

For the wholesale distributor, the transportation function is considerably complicated because of related risks and dangers [48]. In order to win a contract and have sufficient conditions to offer an efficient distributing service, the company needs to provide a comprehensive set of supplementary services supporting the process of distributing which arise some types of costs from involving handling, packing, transferring, customs clearance fee and insurance.

(a) Handling and packaging costs (SC41)

On the role of being a distributor, modern firms tend to supply services which create costs such as packing, staging and handling pallets, customizing orders for fitting typical shelves of stores [27]. Specifically, these costs are paid to staffs who regularly receive, store, retrieve and move the products for operating smoothly the function of delivery. Especially in cases of special goods, distributors will need to spend money on equipping cranes and forklift trucks, gloves, head coverings, and coats for their workers to manipulate safely in a cold condition [8, 11, 33, 49].

(b) Transporting costs (SC42)

Costs for transporting are influenced by many factors such as a collection of market zones that can be served by the distributors, a group of departures and destinations, a set of products, and a series of available transportation modes [50]. Gathering goods from different places for consolidating at the distribution centre is one of the reasons that cause delays in moving and raise the transporting costs [49]. Moreover, this type of cost is also impacted by the availability and condition of infrastructure, the environment and life quality, customs and cargo security, and carrier safety [27].

(c) Customs costs (SC43)

Customs costs are influenced by issues related to the process and speed of goods clearance, settling barriers about differences in culture, language, dealing problems of the poor transportation system and verbose customs procedures [11]. Additionally, in cases of international business, this type of cost is paid for agencies who can help the distributing function of the firm be more flowing and quickly owing to their responsibility in finding the best routes and local carriers for moving products, negotiating conditions with stakeholders, preparing documents needed for customs procedures, receiving goods from customs and transferring them across international borders, and guiding payments for duties and tariffs [33].

(d) Insurance costs (SC44)

Insurance is an obligatory cost for all journeys and is not uniform across routes. Paying for insurance might help companies supplied distributing service to tackle the situations of disruptions during the delivery process [51] such as situations which carriers unintentionally circulate into prohibited roads because of some of the traffic regulations of the government, or carriers encounter hazardous incidents influencing to drivers themselves, other people, and property [52]. Besides, insurance costs can also solve implicit problems relevant to the evacuation at the site of the accident, emergency response, clean-up, environmental damage, and business interruptions [51, 52].

3.3 Structuring the hierarchy model

The authors use the above discussions about four main costs (C1, C2, C3, C4) and 14 sub-costs (SC11, SC12…SC44) to build the FAHP model with 2 levels. In which, Level 0 represents the goal of this study as "evaluating costs of the LVC in Vietnam", while Level 1 includes four major costs incurred from four participants in the LVC and Level 2 indicates 14 sub-costs. These costs are considered

the criteria for the evaluation process in the model. Hence, these costs are denoted as "C", which means "criteria" or "costs" and SCs stands for "sub-criteria" or "sub-costs". During the data analysis section, the authors will use these symbols to simplify the process. Details of the FAHP model are shown in Figure 1.

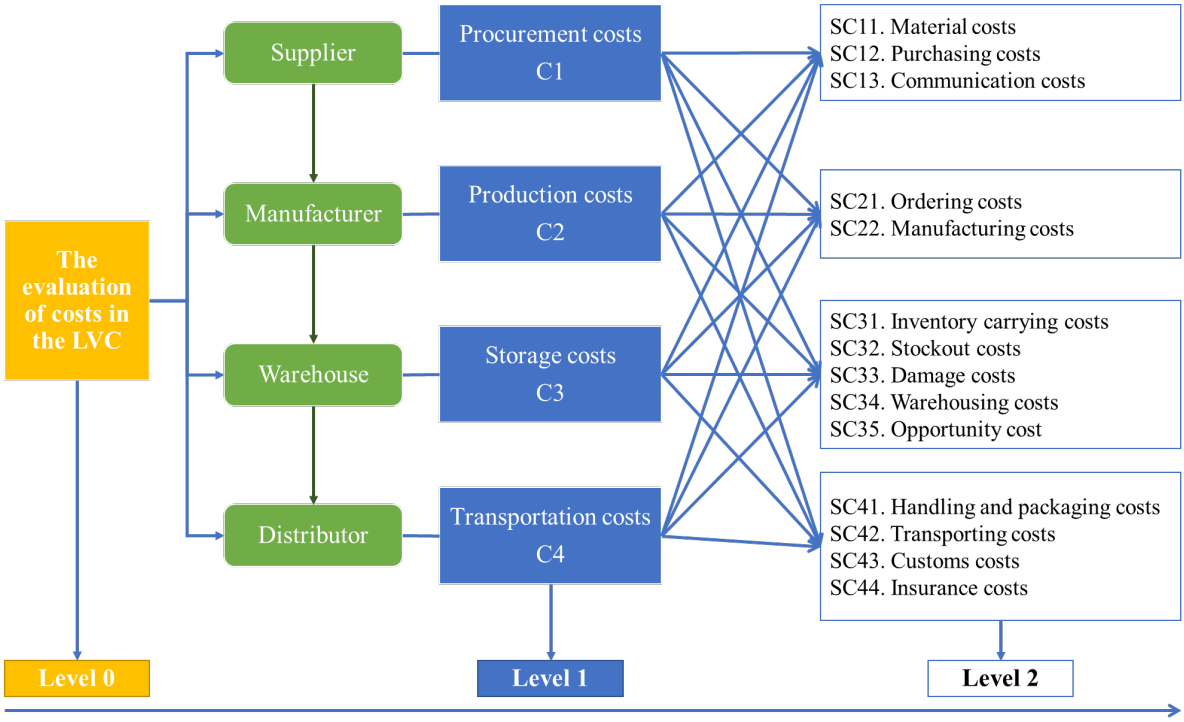

Figure 1. The FAHP research model

4. Methodology

4.1 Questionnaire and data collection

As discussed early, the paper uses the FAHP method to measure the assessment of experts on their perceptions of logistics costs in Vietnam. To do so, the expert questionnaire (also called FAHP-questionnaire) is established. The questionnaire will include 27 pairwise comparisons (from P1-P27) as shown in Table 1.

Table 1. 27 Pairwise comparisons using in the questionnaire

C	C1	C3	C3	C4
P1: C1 vs C2	**P7**: SC11 vs SC12	**P11:** SC31 vs SC32	**P16:** SC32 vs SC33	**P22**: SC41 vs SC42
P2: C1 vs C3	**P8:** SC11 vs SC13	**P12:** SC31 vs SC32	**P17:** SC32 vs SC34	**P23:** SC41 vs SC43
P3: C1 vs C4	**P9:** SC12 vs SC13	**P13:** SC31 vs SC33	**P18:** SC32 vs SC35	**P24:** SC41 vs SC44
P4: C2 vs C3	**C2**	**P14:** SC31 vs SC34	**P19:** SC33 vs SC34	**P25:** SC42 vs SC43
P5: C2 vs C4	**P10**: SC21 vs SC22	**P15:** SC31 vs SC35	**P20:** SC33 vs SC35	**P26:** SC42 vs SC44
P6: C3 vs C4			**P21:** SC34 vs SC35	**P27:** SC43 vs SC44

The 27 pairwise comparisons are sent to 20 logistics experts to give their judgments over the main costs and sub-costs arising in the LVC. These experts will help see among these costs, which costs are the most unreasonable. Thereby, the priorities weights of costs can be able to establish. The evaluation is done based on the FAHP-scales (also known as The linguistic variables or fuzzy numbers-TFNs) [17]. The experts will have 5 degrees to adjust, in which, the Degree 1 represents "equally unreasonable", the Degree 2 shows "weakly more unreasonable", the Degree 3 indicates "fairly more unreasonable", the Degree 4 means "strongly more unreasonable", and the Degree 5 is "absolutely more unreasonable". These five degrees will be converted into the Fuzzy AHP scale as shown in Table 2.

Table 2. The Fuzzy-AHP scale

Degree of logistics costs issue	(+) TFN	(-) TFN
1. Equally unreasonable	(1, 1, 1)	(1, 1, 1)
2. Weakly more unreasonable	(2, 3, 4)	(1/4, 1/3, 1/2)
3. Fairly more unreasonable	(4, 5, 6)	(1/6, 1/5, 1/4)

4. Strongly more unreasonable	(6, 7, 8)	(1/8, 1/7, 1/6)
5. Absolutely more unreasonable	(8, 9, 10)	(1/10, 1/9, 1/8)

The expert questionnaire is set up in both English and Vietnamese. After checking the clarity of the terms, 20 experts who have been working, researching, or using logistics services in Vietnam are selected to direct interviews in 2 weeks. The experts' statistics information is summarized in Table 3. As a result, out of 20 experts, up to 95% are managers and seniors in companies with professions being directly related to logistics services. In particular, up to 75% of companies with more than 100 people. The education level of experts is mainly MSc (65%). Thus, it can be said that the selected experts are those who have extensive experience and deep knowledge in the field of logistics in Vietnam. Therefore, their opinions have a high practical value.

Table 3. Expert information

Information	Category	Frequencies	Percentage
Gender	Female	6	30%
	Male	14	70%
Age	20-30 years old	3	15%
	31-20 years old	13	65%
	41-50 years old	4	20%
Education	MSc	13	65%
	BSc	7	35%
Position	Manager	10	50%
	Senior	9	45%
	Researcher	1	5%
Company field	Logistics	18	90%
	Healthcare	1	5%
	Education	1	5%
Company size	50-100 employees	5	25%
	100-300 employees	6	30%
	300-500 employees	2	10%
	> 500 employees	7	35%

4.2 Formulas to compute fuzzy priorities

To implement the FAHP method, the authors carried out 3 stages as follows:

Stage 1: Testing the Consistency of evaluators

Since the comparison matrix including a total of 27 pairwise comparisons. Therefore, to confirm the comparison process to become reliable, the first stage is to measure the level of consistency in the evaluation of experts. To do so, the authors adopt the consistency ratio (CR). As suggested, CR needs to be smaller than 0.1, if so, the comparison matrix can be confirmed consistently or reliably [15]. In this study, a summary of the CR coefficients of the total 20 experts is shown at the end of each comparison matrix table.

Stage 2: Integrate the individual judgments of evaluator

In order to Integrate the individual judgments of 20 selected experts. The authors adopt the geographic mean approach as it is able to combine the fuzzy weight ($\overline{w_i}$) of evaluators [15, 53, 54]. $\overline{w_i}$ can be calculated as:

$$\overline{w_i} = \left(\prod_{k=1}^{k} \overline{w}_1^k\right)^{\frac{1}{k}}, \text{k} = 1, 2\ldots \text{k}.$$

Where:

$\overline{w_i}$: Integrated fuzzy weight of criterion i of all evaluators

$\overline{w}_1^k$: Fuzzy weight of criterion i of evaluator k.

k: number of evaluators.

Stage 3: Compute fuzzy priorities

After combining 20 evaluators' judgments, the study utilizes the extend analysis method proposed by paper [17]. In this study, let G = {g_1, g_2, g_3…, g_n} be a goal set of the research problem (cost evaluations in the LVC). As suggested, M extent analysis values for each goal is labeled as:

$$M_{g_i}^1, M_{g_i}^1, \ldots, M_{g_i}^1; \text{ i} = 1, 2\ldots \text{n} \quad (1)$$

Where: $M_{g_i}^j (j = ,2, \ldots, m)$

The process of computing fuzzy priorities will be done in four steps as:

1) The value of fuzzy synthetic extent with respect to i^{th} object is defined as:

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \times \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j\right]^{-1} \quad (2)$$

Where:

$$\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} l_j; \sum_{j=1}^{m} m_j; \sum_{j=1}^{m} U_j\right) \quad (3)$$

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{n} l_j;\ \sum_{j=1}^{n} m_j;\ \sum_{j=1}^{n} U_j\right) \quad (4)$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} = \left(\frac{1}{\sum_{j=1}^{n} U_j}; \frac{1}{\sum_{j=1}^{n} m_j;}; \frac{1}{\sum_{j=1}^{n} l_j}\right) \quad (5)$$

2) The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is drawn as:

$$V(M_2 \geq M_1) = \sup_{y \geq x}[\min(\mu_{M_1}(x), \mu_{M_2}(y))] \quad (6)$$

Or it can be identified as:

$$V(M_2 \geq M_1) = hgt\,(M_1 \cap M_2) = \mu_{M_2}(d) =$$

$$\begin{cases} 1, & if\ m_2 \geq m_1 \\ 0, & if\ l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise, \end{cases} \quad (7)$$

Where d is the ordinate of the highest intersection between M_1 and M_2.

3) The degree possibility for a convex fuzzy number can be determined by:

$$V(M \geq M_1, M_2, \ldots, M_k) = V(M \geq M_1) and\ (M \geq M_2) and \ldots and\ (M \geq M_k) = min\, V(M \geq M_i), i = 1,2,3 \ldots, k. \quad (8)$$

Assume that d'(A_i)= min V ($S_i \geq S_k$) For k = 1, 2… n; k ≠ i. (9)

Then the weight vector: W'= (d'(A_1), d'(A_2) … d'(A_n))^T (10)

Where A_i (i= 1, 2,…,n) are n elements.

4) Normalizing the weight vectors via:

W = ((d (A_1), d (A_2) … d (A_n)) ^{T} (11)

Where W now is a non-fuzzy number which is seen as the priority weights of one criterion over another.

5. Data analysis and Findings

5.1 The priority weights of main costs

The fuzzy comparison matrix is indicated in Table 4. The CR is 0.03 which is less than 0.1. This means that the matrix is consistent in level 1 of the hierarchy. Accordingly, to find the priority weights of the main costs, the equation (2) (3) (4) and (5) was utilized to calculate the fuzzy synthesis values. These equations are similarly used for the calculation regarding sub-costs in the next section. The values of C1, C2, C3, and C4 are labeled as S_{C1}, S_{C2}, S_{C3}, S_{C4}.

Table 4. The fuzzy comparison matrix of main costs

C	C1	C2	C3	C4	sum (l,m,u)
C1	(1,1,1)	(0.643,0.933,0.933)	(0.861,1.078,1.078)	(0.966,1.803,2.648)	(3.47,4.814,5.659)
C2	(1.072,1.072,1.555)	(1,1,1)	(1.014,1.302,1.302)	(0.794,1.485,2.127)	(2.809,4.859,5.984)
C3	(0.928,0.928,1.162)	(0.768,0.768,0.986)	(1,1,1)	(0.947,1.866,2.743)	(2.714,4.561,5.89)
C4	(0.378,0.555,1.259)	(0.47,0.673,1.259)	(0.365,0.536,1.056)	(1,1,1)	(1.835,2.764,4.574)
Sum	(3.377,3.554,4.975)	(2.881,3.374,4.178)	(3.24,3.916,4.437)	(3.707,6.154,8.518)	(10.828,16.998,22.107)
S_{C1} = (3.470, 4.814, 5.659) × (1/22.107, 1/16.998, 1/10.828) = (0.157, 0.283, 0.523)					
S_{C2} = (2.809, 4.859, 5.984) × (1/22.107, 1/16.998, 1/10.828) = (0.127, 0.286, 0.553)					
S_{C3} = (2.714, 4.561, 5.890) × (1/22.107, 1/16.998, 1/10.828) = (0.123, 0.268, 0.544)					
S_{C4} = (1.835, 2.764, 4.574) × (1/22.107, 1/16.998, 1/10.828) = (0.083, 0.163, 0.423)					
CR=0.03					

Then, the equation (6) (7) (8) are adopted to ascertain the possibility degree of S_{Ci} over S_{Cj} (i, j = {1, 2, 3, 4, 5}; i ≠j). These equations are similarly used for the calculation regarding sub-costs in the next section.

- $V(S_{C1} \geq S_{C2}) = \frac{(0.127-0.523)}{(0.283-0.523)-(0.286-0.127)} = 0.992$; $V(S_{C1} \geq S_{C3}) = 1$; $V(S_{C1} \geq S_{C4}) = 1$
- $V(S_{C2} \geq S_{C1}) = 1$; $V(S_{C2} \geq S_{C3}) = 1$; $V(S_{C2} \geq S_{C4}) = 1$
- $V(S_{C3} \geq S_{C1}) = \frac{(0.157-0.544)}{(0.268-0.544)-(0.283-0.157)} = 0.963$; $V(S_{C3} \geq S_{C2}) = \frac{(0.127-0.544)}{(0.268-0.544)-(0.286-0.127)} = 0.956$; $V(S_{C3} \geq S_{C4}) = 1$.
- $V(S_{C4} \geq S_{C1}) = \frac{(0.157-0.423)}{(0.163-0.423)-(0.283-0.157)} = 0.689$; $V(S_{C4} \geq S_{C2}) = \frac{(0.127-0.423)}{(0.163-0.423)-(0.286-0.127)} = 0.706$; $V(S_{C4} \geq S_{C3}) = \frac{(0.123-0.423)}{(0.163-0.423)-(0.268-0.123)} = 0.741$.

After comparing those above fuzzy numbers, the minimum degree of possibility or the priority weight is given by using the equation (9) as follows:

- d'(S_{C1}) = min (0.992,1.000,1.000) = 0.992
- d'(S_{C2}) = min (1.000,1.000,1.000) = 1.000
- d'(S_{C3}) = min (0.963,0.956,1.000) = 0.956
- d'(S_{C4}) = min (0.689,0.706,0.741) = 0.689

Applying the equation (10), the weight vector is determined as W'= $(0.992,1.000,0.956,0.698)^T$. This weight vector was normalized using the equation (11). The equation (9), (10), (11). These equations are similarly used for the calculation regarding sub-costs in the next sections. As a result, the weights of the main costs are normalized as (0.272, 0.274, 0.262, 0.192). It can be seen that among the four costs incurred throughout the LVC in Vietnam, all of them are considered unreasonable. Specifically, production costs (C2) and procurement costs (C1) are being assessed to be the highest ones at 27.4% and 27.2% respectively. While, storage costs account for 26.2% and transportation costs are 19.2%. Thus, the LVC in Vietnam under the view of cost evaluation is relatively weak, when costs incurred in the chain are high and divided equally for each stage.

5.2 The priority weights of SC1

Table 5 shows that CR= 0.01<0.1. This means that the comparison matrix is consistent in the second level of the hierarchy. The different values of SC11, SC12, SC13 are denoted as S_{SC11}, S_{SC12}, S_{SC13}.

Table 5. The fuzzy comparison matrix of SC1

SC1	SC11	SC12	SC13	Sum (l,m,u)
SC11	(1,1,1)	(1.148,1.826,2.177)	(0.861,1.725,2.446)	(3.009,4.551,5.623)
SC12	(0.459,0.548,0.871)	(1,1,1)	(0.977,1.714,2.362)	(2.436,3.262,4.233)
SC13	(0.409,0.58,1.162)	(0.423,1,1.023)	(1,1,1)	(1.832,2.58,3.185)
Sum	(1.868,2.127,3.033)	(2.571,3.826,4.201)	(2.838,4.44,5.808)	(7.278,10.393,13.041)
S_{SC11} = (3.009,4.551,5.623) × (1/13.041, 1/10.393,1/7.278) = (0.231,0.438,0.773)				
S_{SC12} = (2.436,3.262,4.233) × (1/13.041, 1/10.393,1/7.278) = (0.187,0.314,0.582)				
S_{SC13} = (1.832,2.58,3.185) × (1/13.041, 1/10.393,1/7.278) = (0.141,0.248,0.438)				
CR=0.01				

- V ($S_{SC11} \geq S_{SC12}$) = 1; V ($S_{SC11} \geq S_{SC13}$) = 1
- V ($S_{SC12} \geq S_{SC11}$) = $\frac{(0.231-0.582)}{(0.314-0.582)-(0.438-0.231)} = 0.739$; V ($S_{SC12} \geq S_{SC13}$) = 1
- V ($S_{SC13} \geq S_{SC11}$) = $\frac{(0.187-0.438)}{(0.248-0.438)-(0.314-0.187)} = 0.792$;

V ($S_{SC13} \geq S_{SC12}$) = $\frac{(0.231-0.438)}{(0.248-0.438)-(0.438-0.231)} = 0.521$

The minimum degree of possibility or the priority weight after comparing those above fuzzy numbers is given as follows:

- d' (S_{SC11}) = min (1, 1) = 1
- d' (S_{SC12}) = min (0.739,1) = 0.739
- d' (S_{SC13}) = min (0.792, 0.521) = 0.521

As a result, the weight vector is given as W'= $(1,0,739,0,521)^T$. After normalizing, the weight vector becomes (0.442,0.327,0.231). Based on these findings, we can see that under procurement costs (SC1), the cost of materials is the highest unreasonable one, accounting for 44.2%. This cost is almost double communication costs (23.1%), while purchasing costs are accounting for 32.7%. Thus, right at the first stage of the LVC in Vietnam, the cost of raw materials is the most unreasonable component.

5.3 The priority weights of SC2

As summarized in Table 6, CR= 0.03<0.1, which means that the consistency of the comparison matrix can be considered acceptable in Level 2 of the hierarchy. The fuzzy values of SC21 and SC22 drawn from the comparison matrix are represented as S_{SC21}, S_{SC22}.

Table 6. The fuzzy comparison matrix of SC2

SC2	SC21	SC22	SUM
SC21	(1,1,1)	(0.952,1.195,1.494)	(1.952, 2.195, 2.494)
SC22	(0.669313,0.837,1.05)	(1,1,1)	(1.669, 1.837, 2.05)
Sum	(1.669,1.837,2.05)	(1.952,2.195,2.494)	(3.621, 4.032, 4.544)
S_{SC21} = (1.952, 2.195, 2.494) × (1/4.544, 1/4.032, 1/3.621) = (0.430, 0.544, 0.689)			
S_{SC22} = (1.669, 1.837, 2.050) × (1/4.544, 1/4.032, 1/3.621) = (0.367, 0.456, 0.566)			
CR= 0.03			

- V ($S_{SC21} \geq S_{SC22}$) = 1
- V ($S_{SC22} \geq S_{SC21}$) = $\frac{(0.430-0.566)}{(0.456-0.566)-(0.544-0.430)} = 0.607$

The minimum degree of possibility or the priority weight after comparing those above fuzzy numbers is given as follows:

- d' (S_{SC21}) = min (1) = 1
- d' (S_{SC22}) = min (0.607) = 0.607

From the above calculations, the weight vector is given as W'= $(1,0.607)^T$ and becomes (0.622, 0.378) after normalizing. Thus, when considering production costs, the evaluators assess the ordering costs to be very high, accounting for 62.2%, nearly double the cost of manufacturing (37%). Thus, the low-cost advantage in Vietnam is not right in the second stage of the LVC when the costs of the production process are too expensive. This reflects the weaknesses of the LVC chain.

5.4 The priority weights of SC3

The fuzzy comparison matrix is summarized in Table 6. The results show that CR= 0.01 <0.1. This means that the matrix is consistent in the second level of the hierarchy. The values of SC31, SC32, SC33, SC34, and SC35 are labeled as S_{SC31}, S_{SC32}, S_{SC33}, S_{SC34}, S_{SC35}.

Table 7. The fuzzy comparison matrix of SC3

SC3	SC31	SC32	SC33	SC34	SC35	SUM
SC31	(1,1,1)	(0.384,0.511, 0.707)	(0.746,0.98, 1.347)	(0.63,0.779, 0.982)	(0.702,0.896, 1.056)	(3.462,4.167, 5.092)
SC32	(1.414,1.958, 2.601)	(1,1,1)	(0.886,1.017, 1.119)	(0.7,0.7, 0.97)	(0.998,0.998, 1.13)	(4.998,5.672, 6.82)
SC33	(0.743,1.02, 1.34)	(0.894,0.984, 1.129)	(1,1,1)	(0.827,0.827, 0.927)	(0.903,0.903, 0.903)	(4.365,4.733, 5.298)
SC34	(1.018,1.283, 1.587)	(1.031,1.428, 1.428)	(1.079,1.21, 1.428)	(1,1,1)	(0.804,1.604, 1.604)	(4.933,6.525, 7.048)
SC35	(0.947,1.116, 1.425)	(0.885,1.002, 1.002)	(1.108,1.108, 1.108)	(0.623,0.623, 1.244)	(1,1,1)	(4.563,4.849, 5.779)
SUM	(5.122,6.377, 7.953)	(4.194,4.925, 5.266)	(4.819,5.315, 6.002)	(3.78,3.93, 5.122)	(4.406,5.401, 5.693)	(22.322,25.946, 30.037)
S_{SC31} = (3.462,4.167,5.092) x (1/30.037,1/25.946,1/22.322) = (0.115, 0.161, 0.228)						
S_{SC32} = (4.998,5.672,6.820) x (1/30.037,1/25.946,1/22.322) = (0.166, 0.219, 0.306)						
Ssc_{33} = (4.365,4.733,5.298) x (1/30.037,1/25.946,1/22.322) = (0.145, 0.182, 0.237)						
Ssc_{34} = (4.933,6.525,7.048) x (1/30.037,1/25.946,1/22.322) = (0.164, 0.251, 0.316)						
Ssc_{35} = (4.563,4.849,5.779) x (1/30.037,1/25.946,1/22.322) = (0.152, 0.187, 0.259)						
CR=0.01						

- V($S_{SC31} \geq S_{SC32}$) = $\frac{(0.166-0.228)}{(0.161-0.228)-(0.219-0.166)} = 0.517$; V($S_{SC31} \geq S_{SC33}$) = $\frac{(0.145-0.228)}{(0.161-0.228)-(0.182-0.145)} = 0.798$; V($S_{SC31} \geq S_{SC34}$) = $\frac{(0.164-0.228)}{(0.161-0.228)-(0.251-0.164)} = 0.416$; V($S_{SC31} \geq S_{SC35}$) = $\frac{(0.152-0.228)}{(0.161-0.228)-(0.187-0.152)} = 0.745$

- $V(S_{SC32} \geq S_{SC31}) = 1$; $V(S_{SC32} \geq S_{SC33}) = 1$; $V(S_{SC32} \geq S_{SC34}) = \frac{(0.164-0.306)}{(0.219-0.306)-(0.251-0.164)} = 0.816$; $V(S_{SC32} \geq S_{SC35}) = 1$
- $V(S_{SC33} \geq S_{SC31}) = 1$; $V(S_{SC33} \geq S_{SC32}) \frac{(0.166-0.237)}{(0.182-0.237)-(0.219-0.166)} = 0.657$; $V(S_{SC33} \geq S_{SC34}) = \frac{(0.164-0.237)}{(0.182-0.237)-(0.251-0.164)} = 0.514$; $V(S_{SC33} \geq S_{SC35}) = \frac{(0.152-0.237)}{(0.182-0.237)-(0.187-0.152)} = 0.216$
- $V(S_{SC34} \geq S_{SC31}) = 1$; $V(S_{SC34} \geq S_{SC32}) = 1$; $V(S_{SC34} \geq S_{SC33}) = 1$; $V(S_{SC34} \geq S_{SC35}) = 1$
- $V(S_{SC35} \geq S_{SC31}) = 1$; $V(S_{SC35} \geq S_{SC32}) = \frac{(0.166-0.259)}{(0.187-0.259)-(0.219-0.166)} = 0.204$; $V(S_{SC35} \geq S_{SC33}) = 1$; $V(S_{SC35} \geq S_{SC34}) = \frac{(0.164-0.259)}{(0.187-0.259)-(0.251-0.264)} = 0.585$

The minimum degree of possibility or the priority weight is given as follows:

- $d'(S_{SC31})$ = min (0.517,0.798,0.416,0.745) = 0.416
- $d'(S_{SC32})$ = min (1.000,1.000,0.816,1.000) = 0.816
- $d'(S_{SC33})$ = min (1.000,0.657,0.514,0.216) = 0.216
- $d'(S_{SC34})$ = min (1.000,1.000,1.000,1.000) =1.000
- $d'(S_{SC35})$ = min (1.000,0.204,0.100,0.030) = 0.585

Then, the weight vector W'= $(0.416,0.816,0.216,1,0.585)^T$. This weight vector is normalized as (0.137,0.269,0.071,0.330,0.193). As a consequence, with respect to the inventory costs, experts assess that the cost of warehousing is the most unreasonable one, accounted for the highest percentage with 33%, followed by stockout costs with 26.9%. While damage costs are not too unreasonable when only accounting for 7.1%. The remaining inventory carrying costs and opportunity cost have respectively 13.7% and 19.3%. Thus, warehousing costs such as building and maintaining the warehouse, regrouping products, or applying computer applications are always the problems that the logistics industry in Vietnam needs to overcome.

5.5 The priority weights of SC4

The fuzzy comparison matrix results are summarized in Table 8. CR=0.01 < 0.1, means that the comparison matrix has a good consistency. The different values of SC41, SC42, SC43 and SC44 are denoted as S_{SC41}, S_{SC42}, S_{SC43}, S_{SC44}.

Table 8. The fuzzy comparison matrix of SC4

SC4	SC41	SC42	SC43	SC44	Sum(l,m,u)
SC41	(1,1,1)	(1.2,2.413, 2.928)	(1.272,2.031, 2.726)	(0.935,1.374, 1.564)	(4.408, 6.817, 8.218)
SC42	(0.341,0.415, 0.833)	(1,1,1)	(1.352,1.741, 1.803)	(0.78,1.55, 2.035)	(3.474, 4.706, 5.67)
SC43	(0.367,0.492, 0.786)	(0.555,0.574, 0.74)	(1,1,1)	(0.872,1.116, 2.473)	(2.794, 3.182, 4.999)
SC44	(0.64,0.728, 1.069)	(0.491,0.645, 1.281)	(0.404,0.896, 1.146)	(,1,1)	(2.794, 3.269, 4.497)
Sum	(2.348,2.635, 3.688)	(3.246,4.632, 5.949)	(4.028,5.668, 6.675)	(3.588,5.04, 7.071)	(9.062, 17.975, 23.385)
S_{SC41} = (4.408, 6.817, 8.218) × (1/23.385, 1/17.975, 1/9.062) = (4.408,6.817,8.218)					
S_{SC42} = (3.474, 4.706, 5.670) × (1/23.385, 1/17.975, 1/9.062) = (3.474,4.706,5.670)					
S_{SC43} = (2.794, 3.182, 4.999) × (1/23.385, 1/17.975, 1/9.062) = (2.794,3.182,4.999)					
S_{SC44} = (2.794, 3.269, 4.497) × (1/23.385, 1/17.975, 1/9.062) = (2.794,3.269,4.497)					
CR=0.01					

- $V(S_{SC41} \geq S_{SC42}) = 1$; $V(S_{SC41} \geq S_{SC43}) = 1$; $V(S_{SC41} \geq S_{SC44}) = 1$
- $V(S_{SC42} \geq S_{SC41}) = \frac{(4.408-5.670)}{(4.706-5.670)-(6.817-4.408)} = 0.776$; $V(S_{SC42} \geq S_{SC43}) = 1$; $V(S_{SC42} \geq S_{SC44}) = 1$

- $V(S_{SC43} \geq S_{SC41}) = \frac{(4.408-4.999)}{(3.182-4.999)-(6.817-4.408)} = 0.140$; $V(S_{SC43} \geq S_{SC42}) = \frac{(3.474-4.999)}{(3.182-4.999)-(4.706-3.474)} = 0.500$; $V(S_{SC43} \geq S_{SC44}) = \frac{(2.794-4.999)}{(3.182-4.999)-(3.269-2.794)} = 0.962$
- $V(S_{SC44} \geq S_{SC41}) = \frac{(4.408-4.497)}{(3.182-4.497)-(6.817-4.408)} = 0.023$; $V(S_{SC44} \geq S_{SC42}) = \frac{(3.474-4.497)}{(3.182-4.497)-(4.706-3.474)} = 0.402$; $V(S_{SC44} \geq S_{SC43}) = 1$.

The minimum degree of possibility or the priority weight is given as follows:

- d' (S_{SC41}) = min (1.000,1.000,1.000) = 1.000
- d' (S_{SC42}) = min (0.776,1.000,1.000) = 0.776
- d' (S_{SC43}) = min (0.140,0.500,0.962) = 0.500
- d' (S_{SC44}) = min (0.023,0.402,1.000) = 0.024

Then, the weight vector is given as W'= (1,0.776, 0.5, 0.024)^T. This weight vector is normalized to as (0.435, 0.337, 0.217, 0.010). Therefore, in relation to transportation costs, the cost of handling and packaging is the highest unreasonable one with 43.5%, followed by transporting costs (33.7%) and customs costs (21.7%). The remaining insurance costs are not a concern when only accounting for 1%. Thus, these results again show the lack of uniformity of the LVC in Vietnam when costs related to handling and packaging costs including packing, staging and handling pallets, customizing orders etc. are very high.

5.6 Synthetizing the priority weights of costs and sub-costs

After calculating the priority weights of costs and sub-costs separately based on the fuzzy comparison matrices, in this section the authors summarize the priority weights and make an overall comparison of 14 types of sub-costs. In so doing, the authors calculate the final weights of sub-costs by taking the weight of sub-costs multiply by the weight of main costs in the same group. The final result is shown in Table 9. Thus, when comparing the costs incurred in the LVC in Vietnam, there are three types of costs, namely warehousing costs (17.4%), manufacturing costs (12%), and stockout costs (10.4%) are evaluated as very unreasonable. Therefore, these three types of costs are the top priority to reduce, while other costs such as material costs (8.9%), communication costs (8.6%), and insurance costs (8.4%) also need to be improved. The remaining costs should also be improved more reasonable.

Table 9. Composite priority weights for costs and sub-costs

Main costs weight		Sub-criteria weight		Final weight*	Percentage
Procurement costs (C1)	0.272	Manufacturing costs (SC11)	0.442	**0.120**	**12%**
		Material costs (SC12)	0.327	0.089	8.9%
		Ordering costs (SC13)	0.231	0.063	6.3%
Production costs (C2)	0.274	Warehousing costs (SC31)	0.622	**0.170**	**17%**
		Stockout costs (SC32)	0.378	**0.104**	**10.4%**
Storage costs (C3)	0.262	Purchasing costs (SC31)	0.137	0.036	3.6%
		Opportunity cost (SC32)	0.269	0.070	7%
		Damage costs (SC33)	0.071	0.019	1.9%
		Communication costs (SC34)	0.330	0.086	8.6%
		Handling & packaging costs (SC35)	0.193	0.051	5.1%
Transportation cost (C4)	0.192	Insurance costs (SC41)	0.435	0.084	8.4%
		Inventory carrying costs (SC42)	0.337	0.065	6.5%
		Transporting costs (SC43)	0.217	0.042	4.2%
		Customs costs (SC44)	0.010	0.002	0,2%
Total	1			1	100%

**Final weight=sub-costs weight*main costs weight in the same group*

6. Conclusion and Implication

6.1 Conclusion

The study used the FAHP method to measure the opinions of 20 experts through their assessment of various costs incurred during the use of logistics services in Vietnam. The reason for this study is because there exists a paradox that Vietnam is a country with the advantage of cost due to cheap labor and raw materials, but logistics costs are being assessed as very high compared to other countries in the region. In order to make the most comprehensive assessment of these costs, the authors used key activities in the LVC including supply, production, warehouse, and distribution corresponding to the four main costs, namely procurement. costs, production costs, storage costs, and transportation costs. These main costs involve 14 sub-costs as discussed in the previous section and represented in Figure 1. As a result, all four main cost categories are being evaluated as very high with similar rates. Of which, the cost of production is the most unreasonable criterion, followed by procurement costs, storage costs, and transportation costs. These results reflect three unreasonable sub-costs including warehousing costs, stockout costs, and manufacturing costs. Thus, it can be concluded that it is necessary to have solutions for the logistics industry in Vietnam to have a strong value chain, closely linked with all parties, so that costs of logistics service can be reduced and the competitiveness of the industry can be improved to compete with other countries in the region such as Singapore, Thailand, and Malaysia.

6.2 Implication

Based on the above results, the authors propose several recommendations to improve the competitiveness of the logistics industry in Vietnam. Given the fact that Vietnam's logistics costs are considerably high compared to the region and the world, the prerequisite solution that businesses operating in this sector need to be mindful of and prioritize to address is balancing between the strategic goal and existing resources to build a strong logistics value chain. Based on that LVC, businesses need to focus on cutting costs of two phases relevant to production and procurement, especially costs of warehousing and stockout. This requires firms to have an accurate and stable demand forecast system, avoiding the situations of storing too many goods or the flow of goods being accelerated dramatically which result in a shortage of supply. In addition, enterprises also need to research to cut down activities that cause a rise in manufacturing costs and material costs. This requires a wise and ingenious strategy right from the first stages of the supply chain, which concentrate on identifying an appropriate supply of materials, designing logical production lines, and making full use of the facilities, equipment and human resources in production.

6.3 Limitations and Future Direction

The research problem is a relatively new and broad topic, so there is plenty of room for further research. Specifically, this study only focused on the key activities in the LVC to find the related costs, ignoring the supporting activities such as information systems, human resources, marketing, etc. In addition, the study evaluates costs in the LVC independently, ignoring the systematic links among costs. Therefore, future research will use the Fuzzy ANP method to measure and assess the network of all costs in the LVC involving both primary and supporting logistics activities. The future study also conducts comparisons in terms of logistics costs with other nations.

References

[1] Banomyong, R., Thai, V. V., & Yuen, K. F. (2015). Assessing the National Logistics System of Vietnam. *The Asian Journal of Shipping and Logistics*, *31*(1), 21–58. https://doi.org/10.1016/j.ajsl.2015.03.002

[2] VLA. (2019). *Vietnam Logistics Survey*. Vietnam Logistics Business Association. http://8express.com.vn/news/vietnam-logistics-survey-15.html

[3] Büyüközkan, G., Feyzioğlu, O., & Nebol, E. (2008). Selection of the strategic alliance partner in logistics value chain. *International Journal of Production Economics*, *113*(1), 148–158. https://doi.org/10.1016/j.ijpe.2007.01.016

[4] Blancas, L. C., Isbell, J., Isbell, M., Tan, H. J., & Tao, W. (2014). *Efficient Logistics: A Key to Vietnam's Competitiveness*. The World Bank. https://doi.org/10.1596/978-1-4648-0103-7

[5] Armstrong & Associates. (2017). *Vietnam Logistics Market 2017*. StoxPlus. http://biinform.com/Reports/E9E-vietnam-logistics-market-report-2017-.html

[6] Dinitzen, H. B., & Bahlbro, D. (2010). *Value Added Logistics in Supply Chain Management* (L. K. Jensen (ed.); 1st ed.). Academica.

[7] Fahimnia, B., Molaei, R., & Ebrahimi, M. H. (2011). Integration in Logistics Planning and Optimization. In *Logistics Operations and Management*. Elsevier Inc.

https://doi.org/10.1016/B978-0-12-385202-1.00018-9

[8] Murphy, P. R., & Knemeyer, A. M. (2018). Contemporary Logistics. In *Pearson Education Limited* (12th ed.). https://doi.org/10.1016/j.ejor.2006.07.009

[9] Engblom, J., Solakivi, T., Töyli, J., & Ojala, L. (2012). Multiple-method analysis of logistics costs. *International Journal of Production Economics*, *137*(1), 29–35. https://doi.org/10.1016/j.ijpe.2012.01.007

[10] Ongkunaruk, P., & Piyakarn, C. (2011). Logistics Cost Structure for Mangosteen Farmers in Thailand. *Systems Engineering Procedia*, *2*, 40–48. https://doi.org/10.1016/j.sepro.2011.10.006

[11] Zeng, A. Z., & Rossetti, C. (2003). Developing a framework for evaluating the logistics costs in global sourcing processes: An implementation and insights. *International Journal of Physical Distribution and Logistics Management*, *33*(9), 785–803. https://doi.org/10.1108/09600030310503334

[12] Dang, V. L., & Yeo, G. T. (2018). Weighing the Key Factors to Improve Vietnam's Logistics System. *The Asian Journal of Shipping and Logistics*, *34*(4), 308–316. https://doi.org/10.1016/j.ajsl.2018.12.004

[13] Zeng, A. Z. (2002). An Optimization Framework for Evaluating Logistics Costs in a Global Supply Chain: an Application to the Commercial Aviation Industry. In J. Geunes, P. M. Pardalos, & H. E. Romeijn (Eds.), *Supply Chain Management: Models, Applications, and Research Directions* (pp. 317–341). Springer. https://doi.org/10.1007/0-306-48172-3_12

[14] Porter, M. E. (1985). *Competitive Advantage, Creating and Sustaining Competitive Performance* (1st ed.). The Free Press.

[15] Saaty, T. L. (1988). What is the Analytic Hierarchy Process? In *Mathematical Models for Decision Support* (pp. 109–121). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-83555-1_5

[16] Chang, C.-W., Wu, C.-R., & Lin, H.-L. (2009). Applying fuzzy hierarchy multiple attributes to construct an expert decision making process. *Expert Systems with Applications*, *36*(4), 7363–7368. https://doi.org/10.1016/j.eswa.2008.09.026

[17] Chang, D. Y. (1996). Applications of the extent analysis method on fuzzy AHP. *EuropeanJournalof OperationalResearch*, *95*(3), 649–655.

[18] Kahraman, C., Cebeci, U., & Ruan, D. (2004). Multi-attribute comparison of catering service companies using fuzzy AHP: The case of Turkey. *International Journal of Production Economics*, *87*(2), 171–184. https://doi.org/10.1016/S0925-5273(03)00099-9

[19] Rehman, A., Mian, S., Umer, U., & Usmani, Y. (2019). Strategic Outcome Using Fuzzy-AHP-Based Decision Approach for Sustainable Manufacturing. *Sustainability*, *11*(21), 6040. https://doi.org/10.3390/su11216040

[20] Saremi, M., Mousavi, S. F., & Sanayei, A. (2009). TQM consultant selection in SMEs with TOPSIS under fuzzy environment. *Expert Systems with Applications*, *36*(2), 2742–2749. https://doi.org/10.1016/j.eswa.2008.01.034

[21] Lam, Y. Y., Sriram, K., & Khera, N. (2019). *Strengthening Vietnam's Trucking Sector: Towards Lower Logistics Costs and Greenhouse Gas Emissions* (No. 135753; Vietnam Transport Knowledge Series). https://documents.worldbank.org/en/publication/documents-reports/documentdetail/165301554201962827/strengthening-vietnam-s-trucking-sector-towards-lower-logistics-costs-and-greenhouse-gas-emissions

[22] World Bank. (2018). *International LPI: Global Rankings 2018*. https://lpi.worldbank.org/international/global

[23] Zhou, X., & Zhang, Q. (2010). Research on construction and generation of logistics value chain. *ICLEM 2010: Logistics for Sustained Economic Development - Infrastructure, Information, Integration - Proceedings of the 2010 International Conference of Logistics Engineering and Management*, *387*(2006), 1028–1034. https://doi.org/10.1061/41139(387)141

[24] Zhou, X. (2013). Research on Logistics Value Chain Analysis and Competitiveness Construction for Express Enterprises. *American Journal of Industrial and Business Management*, *03*(02), 131–135. https://doi.org/10.4236/ajibm.2013.32017

[25] Dinitzen, H. B., & Bohlbro, D. (2012). *Value-Added Logistics in Supply Chain Management*. Academica.

[26] Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (1999). *Designing and Managing the Supply Chain: Concepts, Strategies, and Cases*. McGraw-Hill Education.

[27] Gourdin, K. N. (2006). *Global Logistics Management - A Competitive Advantage for the 21st century* (2nd ed.). Blackwell Publishing.

[28] Jayaraman, V., & Luo, Y. (2007). Creating competitive advantages through new value creation: A reverse logistics perspective. *Academy of Management Perspectives*, *21*(2), 56–73. https://doi.org/10.5465/AMP.2007.25356512

[29] Özsahin, M. E., & Schukraft, S. (2013). Configuration of changeable logistics structures in value chain networks: Identification and analysis of change drivers. In *IFAC Proceedings Volumes (IFAC-PapersOnline)* (Vol. 6, Issue PART 1). IFAC. https://doi.org/10.3182/20130911-3-BR-3021.00036

[30] Harrison, A., Hoek, R. van, & Skipworth, H. (2014). *Logistics Management and Strategy - Competing through the Supply Chain* (5th ed.). Pearson Education Limited.

[31] Antràs, P., & Chor, D. (2013). Organizing the Global Value Chain. *Econometrica*, *81*(6), 2127–2204. https://doi.org/10.3982/ECTA10813

[32] Fusiripong, P., Baharom, F., & Yusof, Y. (2017). Determining Multi-Criteria Supplier Selection towards Sustainable Development of IT Project Outsourcing. *International Journal of Supply Chain Management (IJSCM)*, *6*(3), 258–270. https://ojs.excelingtech.co.uk/index.php/IJSCM/article/view/1772

[33] Waters, C. D. J. (2019). *Logistics: An Introduction to Supply Chain Management*. Macmillan International Higher Education.

[34] Sipsas, K., Alexopoulos, K., Xanthakis, V., & Chryssolouris, G. (2016). Collaborative Maintenance in flow-line Manufacturing Environments: An Industry 4.0 Approach. *Procedia CIRP*, *55*, 236–241. https://doi.org/10.1016/j.procir.2016.09.013

[35] Brax, S. (2005). A manufacturer becoming service provider - Challenges and a paradox. *Managing Service Quality*, *15*(2), 142–155. https://doi.org/10.1108/09604520510585334

[36] Pazour, J. A., Meller, R. D., & Pohl, L. M. (2010). A model to design a national high-speed rail network for freight distribution. *Transportation Research Part A: Policy and Practice*, *44*(3), 119–135. https://doi.org/10.1016/j.tra.2009.11.006

[37] Dev, N. K., Caprihan, R., & Swami, S. (2014). Strategic Positioning of the Push-Pull Boundary within a Supply Chain: An Ordering Policy Co-ordination Perspective. *Operations and Supply Chain Management: An International Journal*, *5*(1), 42–53. https://doi.org/10.31387/oscm0110073

[38] Jeong, I.-J. (2011). A dynamic model for the optimization of decoupling point and production planning in a supply chain. *International Journal of Production Economics*, *131*(2), 561–567. https://doi.org/10.1016/j.ijpe.2011.02.001

[39] Ng, T. W., & Chung, W. (2009). The Roles of Distributor in the Supply Chain–Push-pull boundary. *International Journal of Business and Management*, *3*(7), 28–39. https://doi.org/10.5539/ijbm.v3n7p28

[40] Porter, M. E. (1998). *Competitive advantage – Creating and sustaining superior performance with a new introduction* (2nd ed.). The Free Press.

[41] Cox, A. (2001). Understanding Buyer and Supplier Power: A Framework for Procurement and Supply Competence. *Journal of Supply Chain Management*, *37*(1), 8–15. https://doi.org/10.1111/j.1745-493X.2001.tb00094.x

[42] Andersson, D., & Norrman, A. (2002). Procurement of logistics services—a minutes work or a multi-year project? *European Journal of Purchasing & Supply Management*, *8*(1), 3–14. https://doi.org/10.1016/S0969-7012(01)00018-1

[43] Woo, Y. Y., Hsu, S.-L., & Wu, S. (2001). An integrated inventory model for a single vendor and multiple buyers with ordering cost reduction. *International Journal of Production Economics*, *73*(3), 203–215. https://doi.org/10.1016/S0925-5273(00)00178-X

[44] LeBlanc, S., Yee, S. K., Scullin, M. L., Dames, C., & Goodson, K. E. (2014). Material and manufacturing cost considerations for thermoelectrics. *Renewable and Sustainable Energy Reviews*, *32*, 313–327. https://doi.org/10.1016/j.rser.2013.12.030

[45] Shehab, E. M., & Abdalla, H. S. (2001). Manufacturing cost modelling for concurrent product development. *Robotics and Computer-Integrated Manufacturing*, *17*(4), 341–353. https://doi.org/10.1016/S0736-5845(01)00009-6

[46] Jung, J. Y. (2002). Manufacturing cost estimation for machined parts based on manufacturing features. *Journal of Intelligent Manufacturing*, *13*(4), 227–238. https://doi.org/10.1023/A:1016092808320

[47] Spencer, M. S., Rogers, D. S., & Daugherty, P. J. (1994). JIT Systems and External Logistics Suppliers. *International Journal of Operations & Production Management*, *14*(6), 60–74. https://doi.org/10.1108/01443579410062095

[48] Jamali, M. (2019). Presenting a Location-Routing Problem for Multi-vehicle Hazardous Materials Transport, Considering the Cost Dependent to the Amount of Materials Loaded Mohammad. *International Journal of Supply Chain Management*, *8*(3), 1079–1100. https://ojs.excelingtech.co.uk/index.php/IJSCM/article/view/3371

[49] Bhatnagar, R., & Teo, C.-C. (2009). Role of logistics in enhancing competitive advantage: A value chain framework for global supply chains. *International Journal of Physical Distribution and Logistics Management*, *39*(3), 202–226. https://doi.org/10.1108/09600030910951700

[50] Vidal, C. J., & Goetschalckx, M. (2001). A global supply chain model with transfer pricing and transportation cost allocation. *European Journal of Operational Research*, *129*(1), 134–158. https://doi.org/10.1016/S0377-2217(99)00431-2

[51] Zhen, X., Li, Y., Cai, G. (George), & Shi, D. (2016). Transportation disruption risk management: Business interruption insurance and backup transportation. *Transportation Research Part E: Logistics and Transportation Review*, *90*(October 2000), 51–68. https://doi.org/10.1016/j.tre.2016.01.005

[52] Verter, V., & Erkut, E. (1997). Incorporating Insurance Costs in Hazardous Materials Routing Models. *Transportation Science*, *31*(3), 227–236. https://doi.org/10.1287/trsc.31.3.227

[53] Dyer, R. F., & Forman, E. H. (1992). Group decision support with the Analytic Hierarchy Process. *Decision Support Systems*, *8*(2), 99–124. https://doi.org/10.1016/0167-9236(92)90003-8

[54] Rehman, A., Mian, S., Umer, U., & Usmani, Y. (2019). Strategic Outcome Using Fuzzy-AHP-Based Decision Approach for Sustainable Manufacturing. *Sustainability*, *11*(21), 6040. https://doi.org/10.3390/su11216040