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A Framework to Evaluate and Improve Supply Chain: FAHP Based Case Study on a Supermarket

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A B S T R A C T

Nowadays, the supply chain has become a buzzword in the business field. Only the supply chain can help to lead a business in an organized way. However, in a supermarket, the supply chain is very important, but it needs to ensure better communication with supplier, customer, and internal management too. Each factor of the supply chain has a good effect on itself. The purpose of this research is to explore the important supermarket supply chain factors found in the literature and from supply chain experts and to develop a framework which can help to arrange the criteria in a sequence from most important to the worst by considering each sector of the supply chain. This paper has studied one of the supermarkets in Bangladesh namely Save 'n' Safe. Authors have taken FAHP, one of the tools of MCDM, to figure out the most effective factors. The result reveals that the managing inventory, internal information sharing, and accurate demand forecasting are the most affected factors for the Save 'n' Safe (a supermarket). Finally, some recommendations have been given to improve the existing situation. This study can be used not only in the other supermarkets but also in any other retail or grocery shops.

Keywords: Supply chain, FAHP, Supermarket, Decision making.

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1. Introduction

Supermarket, a market to provide all daily needs from food to households. In 1930, Michael Cullen, started the first supermarket in America [1]. Some private organizations in Bangladesh established the retail chain stores service focusing on the concept of global retailers. The first supermarket in Bangladesh is "Agora" which was launched by Rahimafrooz Superstores Ltd. (RSL) in 2001 [2]. This business is rapidly changing the lifestyle of urban people. So, day by day, it is becoming more and more popular. Now, there are a number of supermarkets here. As a result, the supermarket business is getting more competitive. It has become so tough to earn more

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profit. There are number of variables which effect on this profit. These variables are directly and indirectly integrated with the supply chain of the shop. Besides this, with the changes of market supply and demand, as well as increasing business competition, supply chain performance has become a key factor for supermarket development. To survive, everyone is focusing on supply chain.

Supply chain of an organization can be simply defined as a set of directly involved entities in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer [3]. The supply chain of a supermarket is wider from suppliers to customers. A supermarket usually keeps variety of products and their customers are also from various categories. Maintaining inter supply chain for the management is so complex. Proper performance of the supply chain helps the business to run with more profit.

“Safe 'n' Save” is a reputed supermarket in Khulna, Bangladesh. They receive their goods from both local and outside suppliers, store them and directly sell to customers. The authors have studied to improve the performance of their supply chain. Possible factors which influence the chain of supermarket have been identified. There are some methods to evaluate performance. In this paper, F-AHP Buckley method has been used to rank the factors.

Fuzzy Analytic Hierarchy Process (F-AHP) is a combination of fuzzy theory and Analytic Hierarchy Process (AHP). Fuzzy and AHP both are good fit for decision method. Guo Yuexian et al. [4] proved that the FAHP model was appropriate for the evaluation of supermarket service.

2. Literature Review

Supply chain management is considered as a business strategy. It has evolved over time from a focus on optimizing internal processes of an organization. Lambert and Cooper [5] described that the overall performance of the supply chain is a synergy of the integrated organizations in the process of supply chain management. Mehmeti et al. [6] reviewed some research papers and highlighted the factors that directly or indirectly influence the performance of supply chain. They mentioned the supply chain performance as an aggregated performance of every company in the chain where relationship among them plays a key role. Nandi et al. [7] studied on smallholder farmers who supply fruits and vegetables to supermarket. They collected data from 127 farmers to identify factors based on transaction cost. Abunar et al. [8] described a conceptual framework for supermarket supply chain. Their aim was to help the researchers to utilize the current conditions of supply chain. Abunar SM and Zerban AM [9] facilitate the supply chain management between supermarkets by integrating information systems and technology. The application of information system is prominent in the improvement of the supply chain where technology will help to control business and companies with better relation among stakeholders, suppliers, and customers. Gunasekaran et al. [10] improved the supply chain performance through management capabilities. In order to improve the performance, they analyzed some factors such as supplier development capabilities, market understanding capabilities, information systems capability, and skills/talent management capabilities. Gupta and Abidi [11] explored factors which affect supply chain of IT products. They divided the factors into two parts: Retailer-Supplier Relationship and Retailer-Customer Relationship. Identified factors for retailer-supplier relationship were strategic partnership, information sharing, and use of technology. On the other side, the factors for retailer-customer relationship were customer orientation, customer service, and innovation. Finally, their paper concluded that four latent influences were associated with retailer supplier relationship and five latent influences were associated with retailer customer relationship.

The work [12] introduced an effective tool AHP for dealing with complex decision making problems. Van Laarhoven and Pedrycz [13] proposed the first solution of fuzzy AHP. In their proposed method they used triangular fuzzy numbers and employed the Logarithmic Least Squares Method (LLSM) to generate elements of the priority vector (fuzzy weights) [13]. Buckley [14] analyzed the fuzzy set theory and used trapezoidal fuzzy numbers to express pairwise comparison values.

Meng [15] applied FAHP to evaluate service quality on rural supermarket. In his research, he used AHP to establish the weights and applied the multi-level fuzzy AHP to assess rural supermarket service quality. Their result showed that rural supermarkets won better evaluation in terms of tangibles. Result of FAHP represented that comfortable shopping environment got 3.512 grades, abundant commodity got 3.562 grades, and especially 4.072 grades for payment. They also concluded their study by suggesting to improve service image, to increase employees' knowledge and to make strong employees' awareness of service. Gopalan [16] evaluated the service quality of retail service through fuzzy AHP approach. Their research purpose was to integrate the fuzzy with AHP approach so that it can help the retailers in practicing and judging the priorities of service quality. Their identified dimensions for judging service quality were personal interaction, physical aspects, reliability, and policy [16]. Authors of this paper have applied FAHP to identify and analyze effected supermarket supply chain factors and have tried to provide possible mitigation plans for the highest severity factors.

3. Problem Statement

Supply chain is such a chain of management without which a business cannot run. It works as a network. Problems occurred in any part of the chain basically impact on the whole supply chain as well as entire business. Overall, the supply chain becomes inefficient.

Safe 'n' Save supermarket has been serving here in Khulna, Bangladesh for more than 15 years. Recently, supermarket business has become too competitive here. Products price, products quality, and other important issues are almost same in every supermarket. As the other things remains constant but supply chain. If any supermarket develops their supply chain, then have there any probability to get better result in business strategy development? And, which parts of supply chain should be developed to make sure the betterment of business strategy? Authors have tried to find the answer of the question in this paper through a case study conducted in Safe 'n' Save supermarket.

4. Research Methodology

In this paper, authors have done this research on a renowned supermarket in Bangladesh. At the initial stage of this study, problems related to supermarket have been identified through reading literatures and direct observation of the shop. Then, they have tried to conduct a case study to improve the supply chain. Researchers have collected data in two stages through two ways. Initial interview and initial survey help to understand the situation of the chain and scope to improve it. Next, they collect data through direct interview and survey; remove the unnecessary data and prepare them for final analysis. Authors use FAHP technique to take decision on which parts and factors need to develop for improving the whole supply chain. Finally, they provide some suggestions based on the result. The flowchart in ***Figure 1*** easily represents the methodology of this paper.

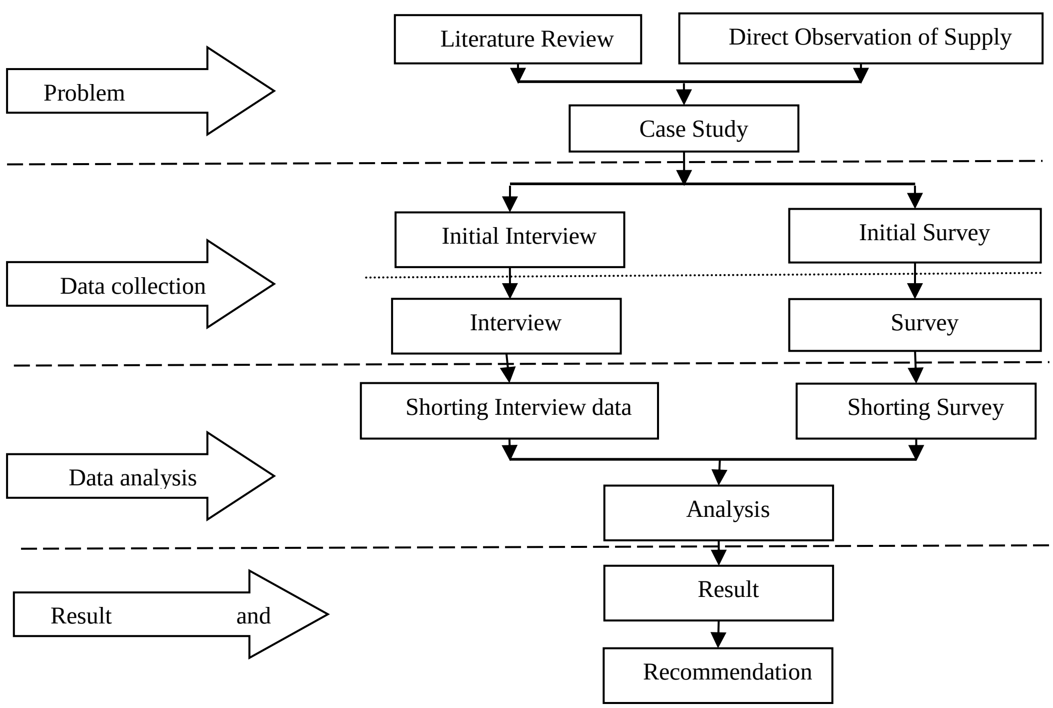

Figure 1. Methodology.

5. Fuzzy Analytic Hierarchy Process (F-AHP)

AHP is a multi-criteria decision making tool. Its main function is to make pairwise comparisons of different alternatives with respective to various criteria. Total analysis is completed in four levels. Integrating fuzzy logic approach helped the AHP to take decision better, especially include vagueness for personal judgments. Buckley [14] developed FAHP method where decision makers can employ fuzzy ratios in place of exact ratios. The pairwise comparison and criteria produce fuzzy positive reciprocal matrices. Geometric mean method is used to determine final fuzzy weights for the alternatives. The highest ranking contains all the undominated and the and lowest ranking contains all dominated issues [14]. This method is implemented to determine the relative importance weights for both criteria and alternatives. The steps of the procedure are as follows:

Step 1. Decision maker compares the criteria or alternatives via linguistic terms shown in ***Table 1***.

Table 1. Linguistic terms and the corresponding triangular fuzzy numbers.

Saaty Scale	Definition	Fuzzy Triangular Scale
1	Equally important (Eq. Imp.)	(1, 1, 1)
3	Weakly important (W. Imp.)	(2, 3, 4)
5	Fairly important (F. Imp.)	(4, 5, 6)
7	Strongly important (S. Imp.)	(6, 7, 8)
9	Absolutely important (A. Imp.)	(9, 9, 9)
2		(1, 2, 3)
4	The intermittent values between	(3, 4, 5)
6	Two adjacent scales	(5, 6, 7)
8		(7, 8, 9)

According to the corresponding triangular fuzzy numbers of these linguistic terms, for example if the decision maker states “Criterion 1 (C1) is Weakly Important than Criterion 2 (C2)”, then it takes the fuzzy triangular scale as (2, 3, 4). On the contrary, in the pairwise contribution matric of the criteria, comparison of C2 to C1 will take the fuzzy triangular scale as (1/4, 1/3, 1/2).

$$\tilde{A}^k = \begin{bmatrix} \tilde{d}_{11}^k & \tilde{d}_{12}^k & \cdots & \tilde{d}_{1n}^k \\ \tilde{d}_{21}^k & \tilde{d}_{22}^k & \cdots & \tilde{d}_{2n}^k \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{d}_{n1}^k & \tilde{d}_{n2}^k & \cdots & \tilde{d}_{nn}^k \end{bmatrix}. \qquad \textit{(1)}$$

The pairwise contribution matric is shown in ***Eq. (1)***, where $\tilde{d}_{ij}^k$ indicates the kth decision maker’s preference of ith criterion over jth criterion, via fuzzy triangular numbers. Here, “tilde” represents the triangular number demonstration and for the example case, $\tilde{d}_{12}^1$ represents the first decision maker’s preference of first criterion over second criterion, and equals to $\tilde{d}_{12}^1 = (2, 3, 4)$.

Step 2. If there is more than one decision maker, preferences of each decision maker ($\tilde{d}_{ij}^k$) are averaged and ($\tilde{d}_{ij}$) is calculated as in the ***Eq. (2)***.

$$\tilde{d}_{ij} = \frac{\sum_{k=1}^{k} \tilde{d}_{ij}^{k}}{k}. \quad (2)$$

Step 3. According to averaged preferences, the pairwise contribution matric is updated as shown in ***Eq. (3)***.

$$\tilde{A} = \begin{bmatrix} \tilde{d}_{11} & \tilde{d}_{12} & \cdots & \tilde{d}_{1n} \\ \tilde{d}_{21} & \tilde{d}_{22} & \cdots & \tilde{d}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{d}_{n1} & \tilde{d}_{n2} & \cdots & \tilde{d}_{nn} \end{bmatrix} \quad (3)$$

Step 4. According to Buckley [14], the geometric mean of fuzzy comparison values of each criterion is calculated as shown in ***Eq. (4)***. Here, $\tilde{r}_i$ still represents triangular values.

$$\tilde{r}_i = \left(\prod_{j=1}^{n} \tilde{d}_{ij} \right)^{\frac{1}{n}}, \quad i = 1, 2, 3, \ldots, n. \quad (4)$$

Step 5. The fuzzy weights of each criterion can be found with ***Eq. (5)***, by incorporating next 3 sub steps.

Step 5a. Find the vector summation of each $\tilde{r}_i$.

Step 5b. Find the (-1) power of summation vector. Replace the fuzzy triangular number, to make it in an increasing order.

Step 5c. To find the fuzzy weight of criterion i ($\tilde{w}_i$), multiply each $\tilde{r}_i$ with this reverse vector.

$$\tilde{w}_i = \tilde{r}_i \times (\tilde{r}_1 + \tilde{r}_2 + \cdots\cdots + \tilde{r}_n)^{-1} = (lw_i, mw_i, uw_i). \quad (5)$$

Step 6. Since $\tilde{w}_i$ are still fuzzy triangular numbers, they need to de-fuzzified by center of area method proposed via applying the ***Eq. (6)***.

$$M_i = \frac{lw_i + mw_i + uw_i}{3}. \quad (6)$$

Step 7. M_i is a non-fuzzy number. But it needs to be normalized by following ***Eq. (7)***.

$$N_i = \frac{M_i}{\sum_{i=1}^{n} M_i}. \quad (7)$$

These 7 steps are performed to find the normalized weights of both criteria and the alternatives. Then by multiplying each alternative weight with related criteria, the scores for each alternative is calculated. According to these results, the alternative with the highest score is suggested to the decision maker.

6. Finding and Data Analysis

After observing the supply chain and reviewing a number of literatures, authors divide the whole supply chain of the super market into three parts: Supplier chain, internal chain, and customer chain. Supplier chain is a chain where activities, goods, money, and information move between supplier and supermarket**.** Internal chain is enclosed within the supermarket itself. The network of customer chain is connected from supermarket to customer. Total three groups were sent to collect these data.

6.1. Identify Factors and Construction of Structure

Discussing with supply chain experts and studying some research papers, the following factors have been identified. ***Table 2*** shows the identified factors for each chain with literature support. After identifying the important factors, authors have developed a hierarchical model based on AHP. ***Figure 2*** is showing the structure of the hierarchical model.

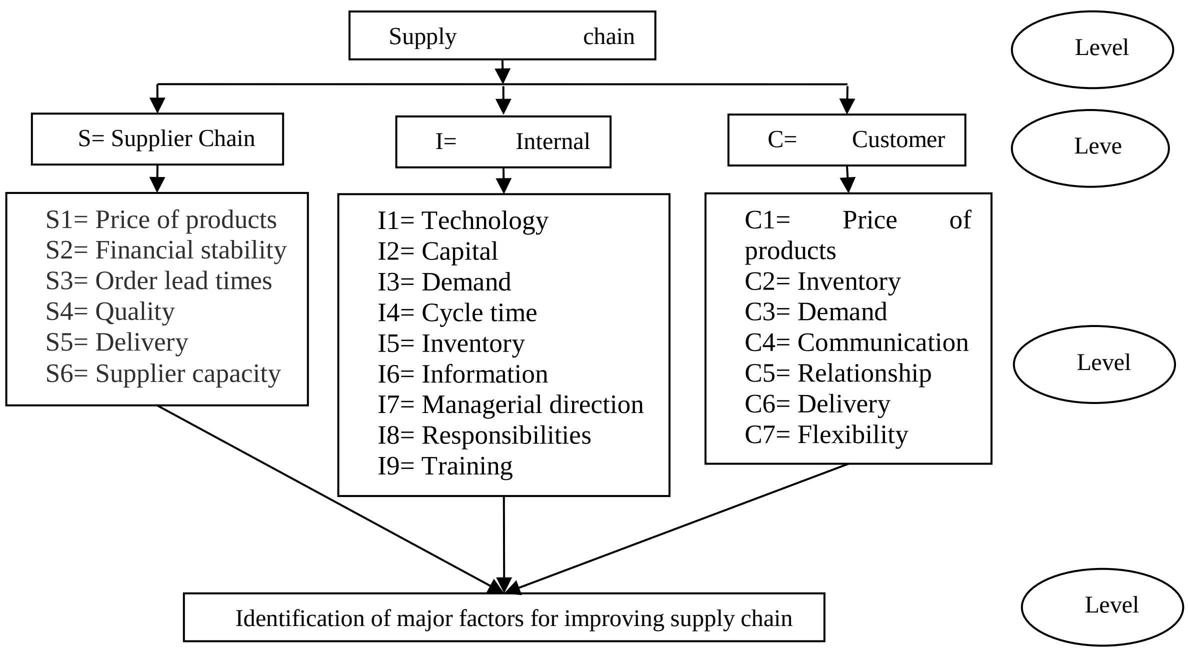

Figure 2. AHP framework for identifying major effected factors.

Table 2. List of factors.

SL	Factors	Explanation	Literature Support
		Factors for supplier chain problems	
1	Price of products	Price is the amount of money at which the buyer and supplier agree to buy and sell of the products.	[17]
2	Financial stability	It is the supplier financial health to continue the business.	[18]
3	Order lead times	It is the time between orders placed to supplier and receive by supermarket.	[17]
4	Quality	It is the degree to which a product meets the requirements of the customer and makes satisfy them.	[17]
5	Delivery	Transferring way and time of goods from one party to another party.	[18]
6	Supplier capacity	It is the ability of the supplier to meet the demand for the supermarket.	[19]
		Factors for internal chain problems	
1	Technology	Adaption of technology makes the supply chain simpler.	[20]
2	Capital	Limitation of capital funding of the supermarket effects on supply chain.	[17]
3	Demand	Accurate demand management attracts more customers.	[21]
4	Cycle time	It is the time elapsed in between the customer order to delivery of goods.	[18]
5	Inventory	Managing inventory keeps good relation with both suppliers and customers.	[21]
6	Information	Information sharing with each other effects on supply chain performance.	[22]
7	Managerial direction	Top management takes all the decision related to supply chain.	[23]
8	Responsibilities	It is the ability to do work eagerly by yourself which improve supply chain.	[24]
9	Training	Teach to the employee to do work accurately.	[25-27]
10	Relationship	It includes internal relationship among employees.	[23]
		Factors for customer chain problems	
1	Price of products	According to customer chain, it is the amount of money customer pay for the products.	[17]
2	Inventory	Stock out or higher inventory effect on supply chain.	[17]
3	Demand	Rapid changes in demand effects on supply chain.	[28]
4	Communication	Communicate with customers to know about market situation.	[17]
5	Relationship	Relationship with all types of customer.	[29]
6	Delivery	An increase in delivery performance means increase in service performance too.	[18]
7	Flexibility	Flexibility to customers ensure better sale of goods and return.	[18] and [29]
8	Satisfaction	Future business actually depends on customer satisfaction.	[23] and [30-31]

6.2. Determining Weights for parts

In order to determine the weights for major parts of the supply chain, three groups were developed including the manager of supermarket. Group A, group B, and group C sequentially observed each part of the supply chain of the supermarket and provided the weight of each part against others. According to their preferences, the averaged pairwise comparison of the criteria is represented by following ***Table 3***. After receiving the data, the next step is to develop pairwise comparison matric. According to ***Table 3***, the pairwise comparison matric is formed in ***Table 4*** for the major parts of the entire supply chain. This table usually provides the clear numeric weight of each part against other parts. In the next step, pairwise contribution matric is updated by using ***Eq. (2)*** and shown in ***Table 5***. In this table, the numerical weight value of the three groups is averaged. Now, using ***Eq. (4)*** the geometric mean of fuzzy comparison values of each part is calculated. For instance, $\tilde{r}_1$ geometric mean of fuzzy comparison values of "Supplier Chain" part is calculated as ***Eq. (4)***.

$$\tilde{r}_i = \left(\prod_{j=1}^{n} \tilde{d}_{ij}\right)^{\frac{1}{n}} = \left[\left(1\times\frac{10}{7}\times\frac{4}{5}\right)^{\frac{1}{3}};\left(1\times\frac{16}{9}\times\frac{7}{6}\right)^{\frac{1}{3}};\left(1\times\frac{9}{5}\times\frac{11}{7}\right)^{\frac{1}{3}}\right] = [1.0484;\ 1.2801;\ 1.4193].$$

Table 3. Pair Wise Comparisons of major part.

						Group A					
SL	A.Imp. (9,9,9)	S.Imp. (6,7,8)	F.Imp. (4,5,6)	W.Imp. (2,3,4)	CRITERION	Eq. Imp. (1,1,1)	CRITERION	W.Imp. (2,3,4)	F.Imp. (4,5,6)	S.Imp. (6,7,8)	A.Imp. (9,9,9)
1					S		I			✓	
2					S		C		✓		
3			✓		I		C				
						Group B					
SL	A.Imp. (9,9,9)	S.Imp. (6,7,8)	F.Imp. (4,5,6)	W.Imp. (2,3,4)	CRITERION	Eq. Imp. (1,1,1)	CRITERION	W.Imp. (2,3,4)	F.Imp. (4,5,6)	S.Imp. (6,7,8)	A.Imp. (9,9,9)
1			✓		S		I				
2					S		C	✓			
3					I	✓	C				
						Group C					
SL	A.Imp. (9,9,9)	S.Imp. (6,7,8)	F.Imp. (4,5,6)	W.Imp. (2,3,4)	CRITERION	Eq. Imp. (1,1,1)	CRITERION	W.Imp. (2,3,4)	F.Imp. (4,5,6)	S.Imp. (6,7,8)	A.Imp. (9,9,9)
1					S		I		✓		
2				✓	S		C				
3				✓	I		C				

Similarly, the geometric means of fuzzy comparison values of all parts are calculated and shown in ***Table 6***. In addition, the total values and the reverse values are also presented. In the last row of the same table, since the fuzzy triangular number should be in increasing order, the order of the numbers is changed. In the last stage of the fifth step, the fuzzy weight of "Supplier Chain" is calculated by using ***Eq. (5)***.

$$\tilde{w}_1 = \lfloor (1.0484 \times 0.1894);(1.2801 \times 0.2125);(1.4193 \times 0.2478) \rfloor = [0.1986; 0.272; 0.3517].$$

Table 4. Pair wise comparison matric of major part.

	Group A		
	Supplier Chain	Internal Chain	Customer Chain
Supplier Chain	(1,1,1)	(1/8,1/7,1/6)	(1/6,1/5,1/4)
Internal Chain	(6,7,8)	(1,1,1)	(4,5,6)
Customer Chain	(4,5,6)	(1/6,1/5,1/4)	(1,1,1)
	Group B		
	Supplier Chain	Internal Chain	Customer Chain
Supplier Chain	(1,1,1)	(4,5,6)	(1/4,1/3,1/2)
Internal Chain	(1/6,1/5,1/4)	(1,1,1)	(1,1,1)
Customer Chain	(2,3,4)	(1,1,1)	(1,1,1)
	Group C		
	Supplier Chain	Internal Chain	Customer Chain
Supplier Chain	(1,1,1)	(1/6,1/5,1/4)	(2,3,4)
Internal Chain	(4,5,6)	(1,1,1)	(2,3,4)
Customer Chain	(1/4,1/3,1/2)	(1/4,1/3,1/2)	(1,1,1)

Table 5. Updated pair wise comparison matric of major part.

	Supplier Chain	Internal Chain	Customer Chain
Supplier Chain	(1,1,1)	(10/7,16/9,9/5)	(4/5,7/6,11/7)
Internal Chain	(17/5,4,19/4)	(1,1,1)	(7/3,3,11/3)
Customer Chain	(2,25/9,7/2)	(1/2,1/2,3/5)	(1,1,1)

Table 6. Geometric means of fuzzy comparison of each part.

Parts	$\tilde{r}_i$		
Supplier Chain	1.0484	1.2801	1.4193
Internal Chain	1.9923	2.3021	2.5921
Customer Chain	0.9946	1.1239	1.2686
Total	4.0352	4.7061	5.2800
Reverse(Power of -1)	0.2478	0.2125	0.1894
Increasing order	0.1894	0.2125	0.2478

Hence the relative fuzzy weights of each criterion are calculated and shown in ***Table 7***. After completing the first five steps of the methodology, the relative non-fuzzy weight of each parts (M_i) is calculated using ***Eq. (6)***. By using non-fuzzy (M_i), the normalized weights of each part are calculated in the seventh step applying ***Eq. (7)***, and tabulated in ***Table 8***. Here, it is found that internal chain absorbs the highest weight which is 0.4911 and the lowest weight was 0.2413 consumed by customer chain.

Table 7. Fuzzy weights of each part.

Parts	$\tilde{w}_i$		
Supplier Chain	0.1986	0.2720	0.3517
Internal Chain	0.3773	0.4892	0.6424
Customer Chain	0.1884	0.2388	0.3144

Table 8. Relative non-fuzzy and normalized weights of each part.

Parts	M_i	N_i
Supplier Chain	0.2741	0.2676
Internal Chain	0.5030	0.4911
Customer Chain	0.2472	0.2413
sum	1.0242	1.00

6.3. Determining Weights of Factors with Respect to Main Parts

The same methodology is applied to find the respective values for factors. That means, this analysis should be repeated for factors of each part. Updated pairwise contribution matric for factors of supplier chain is represented in ***Table 9***. Geometric mean, fuzzy weight, non-fuzzy weight, and normalized weight for supplier chain factors are represented in ***Table 10***. After finding the normalized weight of supplier chain, the same procedure is also applied to find the weight of internal chain factors. From pairwise contribution matric for the factors of "Internal Chain" in ***Table 11***, authors calculated the geometric mean, fuzzy weight, non-fuzzy weight, and normalized weight which are represented in ***Table 12***. At the same way, ***Table 13*** shows the pairwise contribution matric for the factors of "Customer Chain". And, the geometric mean, fuzzy weight, non-fuzzy weight, and normalized weight for customer chain factors are represented in ***Table 14***. In order to get the final result, multiply the normalized weight of major parts with the normalized weight of their factors. ***Table 15*** displays the final score of the factors and their rank.

Table 9. Pair wise contribution matric "Supplier Chain.

	S_1	S_2	S_3	S_4	S_5	S_6
S_1	(1,1,1)	(4,43/9,11/2)	(11/4,31/9,25/6)	(8/3,3,10/3)	(4/5,7/6,11/7)	(2,11/4,17/5)
S_2	(3/4,1,13/9)	(1,1,1)	(5/7,3/4,3/4)	(10/7,7/4,19/9)	(2,22/9,14/5)	(4/3,5/3,2)
S_3	(7/9,8/7,3/2)	(2,7/3,8/3)	(1,1,1)	(13/9,9/5,13/6)	(1,7/5,7/4)	(1,13/9,11/6)
S_4	(5/7,5/7,5/7)	(4,19/4,38/7)	(19/7,17/5,4)	(1,1,1)	(7/5,2,11/4)	(5,49/9,35/6)
S_5	(2,25/9,7/2)	(27/8,4,33/7)	(7/4,19/9,5/2)	(3/2,17/9,7/3)	(1,1,1)	(4,5,6)
S_6	(3/2,11/6,9/4)	(3/4,7/9,5/6)	(1,13/9,11/6)	(3/4,1,10/7)	(1/6,2/9,1/3)	(1,1,1)

Table 10. Relative non-fuzzy and normalized weights of supplier chain.

Factors	$\tilde{r}_i$			$\tilde{w}_i$			M_i	N_i
S_1	1.9167	2.3274	2.7292	0.1536	0.2169	0.3046	0.2250	0.2170
S_2	1.1357	1.3394	1.5301	0.0910	0.1248	0.1708	0.1289	0.1243
S_3	1.1703	1.4585	1.7406	0.0938	0.1359	0.1943	0.1413	0.1363
S_4	1.9514	2.2488	2.5203	0.1564	0.2096	0.2813	0.2157	0.2081
S_5	2.0482	2.4647	2.8866	0.1642	0.2297	0.3222	0.2387	0.2302
S_6	0.7376	0.8928	1.0696	0.0591	0.0832	0.1194	0.0872	0.0841
Total	8.9598	10.7316	12.4763					
Reverse(Power of -1)	0.1116	0.0932	0.0802					
Increasing order	0.0802	0.0932	0.1116					

Table 11. Pair wise contribution matric for the factors of "Internal Chain".

	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9	I_{10}
I_1	(1,1,1)	(10/7,19/9,17/6)	(13/9,9/5,13/6)	(1/6,1/5,1/4)	(1/6,1/5,2/7)	(3/4,7/9,5/6)	(1/6,2/9,1/3)	(4/9,1/2,1/2)	(4/5,7/6,11/7)	(3/4,7/9,5/6)
I_2	(5/6,11/9,5/3)	(1,1,1)	(1/2,5/9,2/3)	(12/7,2,12/5)	(1/6,2/9,1/3)	(1/5,1/4,1/3)	(4/5,8/7,3/2)	(5/7,3/4,3/4)	(10/3,13/3,16/3)	(2,25/9,7/2)
I_3	(19/7,17/5,4)	(5/3,7/3,3)	(1,1,1)	(10/3,13/3,16/3)	(3/4,10/9,3/2)	(5/7,5/7,5/7)	(7/9,8/7,3/2)	(3,11/3,13/3)	(6,7,8)	(4,5,6)
I_4	(4,5,6)	(12/7,2,12/5)	(1/5,1/4,1/3)	(1,1,1)	(3/2,11/6,9/4)	(10/7,16/9,15/7)	(5/7,5/7,5/7)	(2/9,2/7,3/7)	(10/3,13/3,16/3)	(12/5,25/9,19/6)
I_5	(14/3,17/3,20/3)	(4,5,6)	(17/5,37/9,29/6)	(2,11/4,17/5)	(1,1,1)	(4,13/3,14/3)	(19/8,19/7,3)	(7/5,2,11/4)	(14/3,17/3,20/3)	(10/3,13/3,16/3)
I_6	(4/3,5/3,2)	(10/3,13/3,16/3)	(8/3,3,10/3)	(17/5,4,19/4)	(4/9,1/2,1/2)	(1,1,1)	(2,7/3,8/3)	(3,11/3,13/3)	(10/3,13/3,16/3)	(3,11/3,13/3)
I_7	(4,5,6)	(15/4,37/9,9/2)	(11/4,31/9,25/6)	(8/3,3,10/3)	(12/5,11/4,3)	(5/7,3/4,3/4)	(1,1,1)	(2,25/9,7/2)	(2,19/7,27/8)	(5/7,3/4,3/4)
I_8	(4,13/3,14/3)	(2,7/3,2/3)	(4/9,1/2,1/2)	(8/3,11/3,14/3)	(3/2,17/9,7/3)	(4/9,1/2,1/2)	(4/5,7/6,11/7)	(1,1,1)	(3/2,17/9,7/3)	(4/3,5/3,2)
I_9	(2,25/9,7/2)	(1/5,1/4,2/5)	(1/8,1/7,1/6)	(1/5,1/4,1/3)	(1/6,1/5,2/7)	(1/5,1/4,2/5)	(22/7,19/6,13/4)	(7/5,2,11/4)	(1,1,1)	(11/3,13/3,5)
I_{10}	(4/3,5/3,2)	(4/5,7/6,11/7)	(1/6,2/9,1/3)	(1,11/8,12/7)	(1/5,1/4,1/3)	(1/2,1/2,5/9)	(2,7/3,8/3)	(3/4,7/9,5/6)	(3/7,4/9,1/2)	(1,1,1)

Table 12. Relative non-fuzzy and normalized weights of internal chain.

Factors	$\tilde{r}_i$			$\tilde{w}_i$			M_i	N_i
I_1	0.5400	0.6432	0.7738	0.0285	0.0398	0.0574	0.0419	0.0403
I_2	0.7939	0.9759	1.1939	0.0419	0.0604	0.0885	0.0636	0.0612
I_3	1.8455	2.2908	2.7139	0.0973	0.1417	0.2012	0.1467	0.1412
I_4	1.1359	1.3533	1.6116	0.0599	0.0837	0.1195	0.0877	0.0844
I_5	2.7732	3.3720	3.9484	0.1462	0.2086	0.2927	0.2158	0.2077
I_6	2.0132	2.3774	2.7442	0.1061	0.1471	0.2034	0.1522	0.1465
I_7	1.8900	2.1728	2.4462	0.0996	0.1344	0.1813	0.1385	0.1333
I_8	1.2612	1.4971	1.7372	0.0665	0.0926	0.1288	0.0960	0.0924
I_9	0.5981	0.7274	0.9041	0.0315	0.0450	0.0670	0.0478	0.0461
I_{10}	0.6405	0.7544	0.8934	0.0338	0.0467	0.0662	0.0489	0.0470
Total	13.4916	16.1642	18.9668					
Reverse(Power of -1)	0.0741	0.0619	0.0527					
Increasing order	0.0527	0.0619	0.0741					

Table 13. Pair wise contribution matric for the factors of "Customer Chain".

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	(1,1,1)	(17/5,17/5,17/5)	(7/5,2,11/4)	(16/3,19/3,22/3)	(14/3,17/3,20/3)	(7/3,3,11/3)	(7/5,2,11/4)	(3/2,11/6,20/9)
C_2	(12/7,2,19/8)	(1,1,1)	(1,13/9,11/6)	(2,25/9,7/2)	(7/5,2,11/4)	(1,1,1)	(4/5,7/6,11/7)	(1/2,1/2,3/5)
C_3	(3/2,17/9,7/3)	(12/5,25/9,19/6)	(1,1,1)	(4,5,6)	(3,11/3,13/3)	(4/3,5/3,2)	(13/9,9/5,13/6)	(3/2,11/6,9/4)
C_4	(1/7,1/6,1/5)	(4/5,7/6,11/7)	(1/6,2/9,1/3)	(1,1,1)	(1,1,1)	(1/6,2/9,1/3)	(1/6,2/9,2/7)	(1/8,1/8,1/7)
C_5	(1/7,1/6,2/9)	(3/2,17/9,7/3)	(1/2,1/2,2/5)	(1,1,1)	(1,1,1)	(1/5,1/4,1/3)	(2/9,2/7,3/7)	(1/6,2/9,1/3)
C_6	(1/2,1/2,3/5)	(1,1,1)	(3/4,7/9,5/6)	(4,5,6)	(10/3,13/3,16/3)	(1,1,1)	(15/7,5/2,3)	(12/7,2,12/5)
C_7	(3/2,17/9,7/3)	(2,25/9,7/2)	(19/7,17/5,4)	(5,17/3,19/3)	(8/3,11/3,14/3)	(2,19/7,17/5)	(1,1,1)	(4/9,1/2,1/2)
C_8	(19/7,17/5,4)	(7/3,3,11/3)	(2,11/4,17/5)	(7,23/3,25/3)	(4,5,6)	(12/5,11/4,3)	(3,11/3,13/3)	(1,1,1)

Table 14. Relative non-fuzzy and normalized weights of customer chain.

Factors	$\tilde{r}_i$			$\tilde{w}_i$			M_i	N_i
C_1	2.2024	2.7035	3.1737	0.1350	0.1928	0.2707	0.1995	0.1924
C_2	1.0926	1.3363	1.5790	0.0670	0.0953	0.1347	0.0990	0.0955
C_3	1.8255	2.1916	2.5649	0.1119	0.1563	0.2188	0.1623	0.1566
C_4	0.3062	0.3589	0.4324	0.0188	0.0256	0.0369	0.0271	0.0261
C_5	0.4113	0.4769	0.5529	0.0252	0.0340	0.0472	0.0355	0.0342
C_6	1.4276	1.6061	1.7963	0.0875	0.1146	0.1532	0.1184	0.1142
C_7	1.7847	2.1575	2.5284	0.1094	0.1539	0.2156	0.1596	0.1540
C_8	2.6748	3.1895	3.6873	0.1639	0.2275	0.3145	0.2353	0.2270
Total	11.7252	14.0205	16.3148					
Reverse(Power of -1)	0.0853	0.0713	0.0613					
Increasing order	0.0613	0.0713	0.0853					

Table 15. Aggregated results for each factors according to each part of the supply chain.

Factor	Major part	Relative weight of major part	Relative weight of factor	Total Score	Rank
S_1	Supplier Chain	0.2676	0.2170	0.0581	6
S_2	Supplier Chain	0.2676	0.1243	0.0333	15
S_3	Supplier Chain	0.2676	0.1363	0.0365	14
S_4	Supplier Chain	0.2676	0.2081	0.0557	7
S_5	Supplier Chain	0.2676	0.2302	0.0616	5
S_6	Supplier Chain	0.2676	0.0841	0.0225	21
I_1	Internal Chain	0.4911	0.0403	0.0198	22
I_2	Internal Chain	0.4911	0.0612	0.0300	16
I_3	Internal Chain	0.4911	0.1412	0.0693	3
I_4	Internal Chain	0.4911	0.0844	0.0414	11
I_5	Internal Chain	0.4911	0.2077	0.1020	1
I_6	Internal Chain	0.4911	0.1465	0.0719	2
I_7	Internal Chain	0.4911	0.1333	0.0654	4
I_8	Internal Chain	0.4911	0.0924	0.0453	10
I_9	Internal Chain	0.4911	0.0461	0.0226	20
I_{10}	Internal Chain	0.4911	0.0470	0.0231	18

Factor	Major part	Relative weight of major part	Relative weight of factor	Total Score	Rank
C_1	Customer Chain	0.2413	0.1924	0.0464	9
C_2	Customer Chain	0.2413	0.0955	0.0230	19
C_3	Customer Chain	0.2413	0.1566	0.0378	12
C_4	Customer Chain	0.2413	0.0261	0.0063	24
C_5	Customer Chain	0.2413	0.0342	0.0083	23
C_6	Customer Chain	0.2413	0.1142	0.0276	17
C_7	Customer Chain	0.2413	0.1540	0.0372	13
C_8	Customer Chain	0.2413	0.2270	0.0548	8

7. Result and Discussion

In this study, the authors have noted six factors from supplier chain, ten factors from internal chain and eight factors from customer chain. According to AHP, authors have also found the hierarchy structure in ***Figure 2***. Microsoft Excel was used for solving FAHP matrices. They have found non-fuzzy and normalized weight for each major part in ***Table 8***. It has been seen that internal chain carries the highest normalized weight which is 0.4911. But, the weight of other two parts is very closely – supplier chain has weighted 0.2676 and customer chain has weighted 0.2413. Similarly, weights for all factors with respect to main parts have been identified using Microsoft Excel software and shown in tables. ***Table 10***, ***Table 12***, and ***Table 14*** are representing the non-fuzzy weights and normalized weights for factors of "Supplier Chain", "Internal Chain" and "Customer Chain", respectively. Final result has been found by aggregating relative weight of major parts and relative weight of factors. ***Table 15*** discloses the final result of this research. Buckley FAHP method has provided the highest score to inventory management of internal part. Inventory of the supermarket mainly effects on the total supply chain of this supermarket. It is showing a total score of 0.1020. So, first of all, the authority of the shop should focus on the inventory management to improve supply chain. Again, information and demand of internal chain have taken the second and third rank; their scores are 0.0719 and 0.0693, respectively. Communication with customers has covered the lowest score. At last stage, the authority should focus on this.

8. Recommendation

Possible suggestions to improve top eight factors have been noted. The authors have analyzed and discussed with experts and supermarket managers to find the improving way. ***Table 16*** shows the suggestions for major eight factors.

Table 16. Suggestions for major eight factors.

Improvement factor	Major part	Suggestions
Inventory	Internal Chain	- Be careful to do accurate forecasting of demand. - Classify all the products into suitable categories using ABC, FNS techniques. - Use EOQ model before ordering goods. - Keep monitoring on goods. - Strictly maintain the safety stock limit.
Information	Internal Chain	- Solve the internal issues like incentive and facilities among the employers. - Install reliable and user-friendly IT equipment for sharing information. - Develop a trusted network for individuals to share information. - Provide better training to the employers.
Demand	Internal Chain	- Decision on demand management should be taken from group analysis rather than a single manager. - Gather appropriate knowledge of market and customers behavior to do accurate demand forecast. - Identify seasonal demand accurately. - Consider the discounts with demand calculation. - Identify the targeted consumer groups.
Managerial Direction	Internal Chain	- Goal and objective should be identified and fixed. - Design the better operating strategies including pricing methods, sales objectives, and advertising budgets. - Proper allocation of capital. - Redesign of store layout, product mix, promotion, process of packaging, and delivery of products.
Delivery	Supplier Chain	- Measure the capacity of supplier before selecting. - Avoid third parties as a supplier to get faster delivery. - Ensure the reliability of delivery. - Develop delivery strategies and appropriate transportation way.
Price of product	Supplier Chain	- Avoid third parties as a supplier to reduce product cost. - Improve dimensional weight during shipping. - Try to remove excess materials as much as possible. - Develop a long term relationship with suppliers to get price negotiation.
Quality	Supplier Chain	- Check the quality of products before receiving from supplier. - Prepare the right environment to the warehouse. - Periodical benchmarking of product quality with the products of other suppliers.
Satisfaction	Customer Chain	- Advice the customers to buy the best products depending on their needs. - Provide training to the staff on well behavior. - Avoid selling expired products.

9. Conclusion and Future Work

In this study, the supply chain of a supermarket was analyzed. Performance measurement and improvement studies were looked over the entire supply chain. All participants in the supply chain attended on this study. In addition, they are committed to common goals. This research found that every factor from any side of the supply chain effect on the performance of entire supply chain. In order to improve or optimize the supply chain, it is required to find out the most effective factors. Because, the priority of factors usually vary based on the needs of the participants. However, in this paper, authors identified the possible factors from all sides. Next, they applied the Fuzzy-AHP technique to find weight of each factor. Moreover, the analysis considers the weight of individual part of the chain. This paper hinted the manager of “Save n safe” supermarket to focus on inventory management, information sharing, demand forecasting, and managerial direction at first. After solving them, they should focus on supplier chain to improve product delivery time and strategy, price of products and quality of products. Prior research has represented overall criteria or factors from single supply chain. It provides a crucial problem to the top managers to take decision on exactly where they need to improve. This research combined the fuzzy with AHP technique and helped to find the supply chain factors of “Save n safe” supermarket alone with sector. Finally, the supply chain performance of the supermarket was improved by implementing the suggestions. This research is so flexible. In future, anyone can pick out more important factors or can divide the supply chain into more small part.

10. Limitation

Although the authors have done this research in a combination of theoretical and practical field, it has some constraints. Firstly, most of the considered factors in this study are subjective. So, it is always not possible to take accurate measurement of the factors. Secondly, staffs and other participants in this research were busy with their work. As a result, researchers could not get the enough time to consult deeply. Last but not the least, limited number of interviewers were considered in this study. In future, this number should be increased.

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