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RESEARCH PAPER

Identifying and Ranking Supply Chain Management Damages Using Analytic Network Process (FMCG Case Study)

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ABSTRACT
Supply chain management is a set of used methods for the efficient integration of suppliers, manufacturers, warehouses, and sellers to respond to customer requirements in order to reduce system costs and distribute products at a right place and right time. This study aims to identify and rank the supply chain damages using the analytic network process as a practical case in a fast-moving consumer goods (FMCG-food industry) company. Firstly, the supply chain damages are explored according to the literature review. In the next step, the most important damages are identified into four clusters of supply: supply, production, distribution, and support. Then, the weights of each identified damage based on its effects on other damages are calculated by using the analytic network process approach. According to the results, the most important supply chain damages include logistics, distribution, competition, and changing market tastes. The obtained results can provide practical discussion and solutions for similar companies to improve their market share and ensure customer satisfaction.

KEYWORDS: *Analytic network process, Supply chain, Damage, FMCG, Ranking.*

1. Introduction

As a strategic thinking approach, organizations increase their competitive ability to standardize and improve their internal processes. They try to utilize improvement opportunities in their supply chain network to compete in global markets efficiently [1]. High quality and lower cost are two most important factors. Perhaps, the prevailing thought is that robust engineering and design, as well as coherent production operations, is a prerequisite for achieving market demands and market share. For this reason, organizations make their efforts for efficiency improvements. By increasing diversity in customers' expected patterns, organizations increasingly become more interested in enhancing the flexibility of product lines and developing new products to satisfy customer needs. Therefore, many industry executives find that the improvement of internal processes and flexibility in a company's capabilities are not sufficient for its on-going presence in the market and for delivering the best quality products or services to clients; therefore, suppliers and buyers should also cooperate with parameters such as the best quality, more flexibility, and the lowest cost.

Strong linkages between suppliers and customers are required for such cooperation [2]. Furthermore, distributors of products should be closely associated with market development approaches, because they are influenced by the demand pull and are further close to the consumers, too [3]. Therefore, simultaneous planning for product and supply chain is a key factor [4]. Through this approach, the supply chain management and performance management emerged. The evaluation of supply chain performance regarding critical factors can create greater value for stakeholders and increase the competitiveness of the supply chain [5]. Supply chain management includes the key business processes across the network of organizations [6]. Supply Chain Management (SCM) includes the main activities such as forecasting, planning, purchasing, inventory management, information management, quality assurance, scheduling

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production, distribution, delivery, disposal, and customer service ([7], [8]).

According to Mejza and Wisner, it is required to integrate logistics, marketing, and operations-oriented processes across supply chain [9]. Gunasekaran and McGaughey mentioned the extended scope of supply chain management beyond material management, partnership, and information technology to the total quality management areas such as management commitment, organizational structure, training, and behavioral issues [10]. Borade and Bansod (2007) believed that "usually in supply chain management the emphasis is on performance measures dealing with suppliers, delivery performance, customer service, and inventory and logistics costs" [11]. The main functional areas of logistics in supply chain management are network design, information technology, transportation, inventory and storage, warehousing, materials handling, loading and unloading, and packaging and re-packaging [12].

In most studies, focusing on the integration of managing materials and information flows between stakeholders in a supply chain to create value is seen to be an essential consideration. Appropriate circulation and data transfer make the processes more efficient and easier to manage. In the supply chain, the issue of consistency in activities is highly critical. Coordinated and appropriate information management among partners (customers to suppliers) will have an increasing effect on decision-making, speed, accuracy, quality, and other aspects [12]. Logistic management as a key section in supply chain management covers all physical activities from the raw materials procurement process to the final product/service including transportation activities, warehousing, production schedules, etc. Relationship management is one of the most vital issues in the supply chain too and includes a significant effect on all areas in the supply chain and its performance level. Many of the initial failures in the supply chain result from the weak transfer of requirements and expectations from one side to the other side in the supply chain. According to Uca et al. (2017), trust in the supply chain positively affected firm performance and increased the supply chain collaboration [13]. They used structural equation modeling to clarify the relationship between trust in the supply chain and a firm's performance through supply chain collaboration and collaborative advantage [13]. Zainahand and Rosidah (2014) proposed a structural framework that demonstrated trust and information sharing with significant effect on the level of relationship commitment of the wholesalers, distributors, and retailers with their key trading partners [14]. Therefore, trust among partners and a reliable plan for them are critical elements that ensure critical success in a supply chain.

Supply chains face various kinds of damage and risk that reduce their efficiency and affect business performance. Each of the supply chain processes has its own complexity and damage as categorized into different groups of production, distribution, management information, etc. Exploring damages along the supply chain is required to adopt effective solutions. Identifying and ranking the aforementioned damages using the analytic network process (ANP) are the main objectives of this study. In the present study, the following questions are answered: What are the most important damages in the supply chain? What are the most important damages in the FMCG supply chain? What are the priorities of supply chain damages in the studied company? To answer the mentioned questions, at first, the damages of an FMCG company focused on supplier's relationship are identified by reviewing the literature. Damages are customized by designing a questionnaire and using experts' opinion. Then, the weight and rank of damages are determined by using the analytic network process. Finally, an analysis is provided in relation to the research findings.

2. Literature Review

The intensification of the global competitive world in a constantly changing environment has urged the need for appropriate responses from companies with an emphasis on their flexibility with respect to a competitively uncertain environment. Today's organizations need to manage their supply chain effectively to realize the competitive advantage and expectations of stakeholders for more market share. Supply chain management emphasizes the adaptability and flexibility of companies and considers the ability to react fast and effectively to market changes and customer needs and expectations as agility.

Logistics capabilities have a major role in achieving supply chain agility [15], which leads to an adaptive marketing strategy and competitive advantages. Flexibility and agility allow customers to meet their expectations more efficiently [16]. In this regard, effective supply chain management is one of the main factors for the appropriate relationship between the suppliers, the various stages of production, and customers. Reducing working capital, taking assets off the balance sheet, accelerating cash-to-cash cycles, increasing inventory turns [17], reducing costs and inventories, increasing customer satisfaction, and continuous improvement are the corporate strategic objectives of supply chain management. Throughout the process of accomplishing the aforementioned objectives of a supply chain, many damages and risks may occur in the form of complexity.

The most important damages are multiplicity of decision-making ([18], [19], and [20]) and uncertainty ([17], [18], [19], [20], and [21]). Perona and Miragliotta (2004) suggested that controlling the complexity within manufacturing and logistics systems could improve efficiency and effectiveness of a supply chain [22]. They emphasized that there were two different kinds of levers to control complexity: complexity reduction and management levers. Due to the fact that supply chain is involved in various organizations, the consistency and coherence between these organizations is very important. Uncertainty in demand forecasting [20] affected by competition, prices, technological development, and the overall level of customer engagement could be a major damage in the supply chain. Demand uncertainty occurs by changing information, and the quality of responding along the supply chain causes bullwhip effects [23] "Bullwhip is the result of system-imposed uncertainty resulting from a supplier discount scheme operating in a retail supply chain" ([24] and [25]).

Uncertainty in delivery time [17] is introduced as a critical damage depending on the factors such as machine failure in the linear production process, material quality problems, etc. If a part of the supply chain is not well connected to other sectors, inconsistency occurs. In this case, supply chain sectors are unaware of some issues, or become aware too late. Some results of inconsistency in supply chain are the bullwhip effect and deceptive stock. When the product is in the wrong place or the amount of the inventory is incorrect and customers cannot buy it in spite of its existence, deceptive stock will occur. According to Ghiani et al. (2004), "supply chains are complex logistics systems, in which raw materials are converted into products and are then distributed to end users through several steps" [26]. The most important challenge in supply chain is the risk of an uncertain future [27]. According to Pettit, because of turbulent changes, supply chain needs the ability to survive and to adapt to these changes in the form of resilience [27]. He identified critical linkages between the inherent vulnerability factors and controllable capability factors along the supply chain management. Carlsson et al. (2009) explained the supply chain in its entirety, its participants, and the planning problems arising along the chain. They focused on planning problems [28]. They divided the planning problems into strategic, tactical, and operative in a supply chain matrix.

Sarkis et al. (2011) introduced nine theories based on green supply chain management such as complexity theory. They mentioned that by increasing complexity, it becomes more difficult to plan and predict their organizational actions [29]. Teller et al. (2012) identified a field for improving the implementation of supply chain management [30]. A conceptual model was created to suggest the internal SCM conditions and link the adoption of SCM processes as SCM implementation records. Their research showed that the conditions of internal supply chain management, especially information and human resources, were the main drivers for improving the overall level of supply chain management. They mentioned that the risk and benefit must be shared between the company and other members in the corresponding supply chain. Forecasting processes in supply chain creates complexity and it is difficult to control inventory [31]. Wu and Choi (2010) mentioned that one of damaged risk in the supply chain partner relationship was confliction. An inappropriate relationship could be damaging [32].

Tummala and Schoenherr (2001) proposed a structured and comprehensive approach for managers to assess and manage risks in supply chains [33]. Their proposed approach is divided into "risk identification, risk measurement, and risk assessment; risk evaluation, risk mitigation, and contingency plans; and risk control and monitoring via data management systems. Transaction costs, supply risk, supplier responsiveness, and supplier innovation were defined as complexity of a system ([34] and [29]). They introduced supply base complexity in three dimensions including "the number of suppliers in the supply base, the degree of differentiation among these suppliers, and the level of inter-relationships among the suppliers". They proposed a complexity theory for green supply chain management for better management. Berrin and AlperKonuk (2013) suggested a model to reduce damages of Third-Party Logistics companies [35]. Mensah and Merkuryev believed that “competition among companies urged them to operate in uncertainties, whereby high risks are faced” in supply chain [36].

Zepedaab et al. (2016) investigated risk management in the supply chain and modeled their problem using the game-theoretic model [37]. Using accurate information obtained from hospitals in California, this study examined the effects of a potential reduction in dependencies on multi-hospital organizations while monitoring their service performance. The results indicated that while dependency for local, regional, and national organizations reduced the effects of weakening under the logistics service infrastructure, the effectiveness would grow due to the reduction of dependency for local organizations.

Ganji and Hayati (2016) identified and assessed the risks in the supply chain of a manufacturer company [38]. They used a multiple decision-making approach to determine the ranking of identified risks. According to their research results, risks related to procurement and supplier were identified and introduced as the most critical risks. KianiMavi et al. (2016) considered the supplier selection criteria in the context of supply chain risk management [39]. These criteria included quality, on-time delivery, and performance history. They mentioned six risks in the supply chain including supply risk, demand risk, manufacturing risk, logistics risk, information risk, and environmental risk. These criteria and risks were considered for evaluating suppliers. Based on their research results, demand risk is the most important factor. Environmental risk is identified as an important risk in supply chain, and managing the green supply chain with emphasis on environmental aspect is an important issue for industry ([40] and [41] and [42]). ISO14000 certification may reduce environmental risks, and the application of ISO 9000 certification may reduce the risk of poor-quality purchases too [40]. F. Israel et al. (2017) considered specific features of spare parts supply chains [43]. According to their research, intermittent behavior (demand pattern) and distribution costs are specific features that are considered as complexity. They believed that the complexity occurred because of the large number of decisions that must be coordinated along the supply chain. Planning processes may be identified as complexity [44]. According to Alsobhi et al. (2018), “in a supply chain system, products get damaged during shipping due to transportation hazards and poor packaging” [45]. They emphasized appropriate packaging for reducing cost at each stage of the supply chain. They proposed a mathematical model to minimize the total costs including damage costs, shipping costs, and packaging cost.

Changes in demand in the market and short product life cycle, cause high pressure for organizations to produce new products, especially in major fast-moving consumer goods (FMCG) company [4]. It can be concluded that supply chain management consists of many factors and variables that should be closely coordinated, and risk and damages occur in all sections of SCM. In this study, damages are considered with focus on uncertainty and inconsistency. According to the literature, the kind of complexity may be different in different industries; however, they usually occurred due to uncertainty and inconsistency. There are papers in the literature that mentioned supply chain damages and risks. The related papers are summarized in Table 1.

Tab. 1. Summary of research subjects

References	Research Subject
Tummala and Schoenherr (2001)	Their proposed approach focused on risk controlling and monitoring via data management systems in supply chain.
Perona and Miragliotta (2004)	They emphasized two different kinds of levers to control complexity including complexity reduction and management levers.
Pettit (2008)	They identified critical linkages between the inherent vulnerability factors and controllable capability factors in supply chain.
	They divided the planning problems into

Carlsson et al. (2009)	strategic, tactical, and operative in a supply chain matrix.
Sarkis et al. (2011)	They introduced nine theories based on green supply chain management focusing on complexity that causes difficulty to plan and predict organizational actions.
Teller et al. (2012)	They emphasized the conditions of internal supply chain management, especially information and human resources and adoption of SCM processes focused on sharing risk and benefit between the company and other members in its supply chain.
Berrin and AlperKonuk (2013)	They suggested a model to reduce damages of Third-Party Logistics companies.
Zepedaab et al. (2016)	They investigated risk management in the supply chain and modeled their problem using the game theory model in hospitals.
Ganji and Hayati (2016)	They used a linear assignment method as a method of multiple decision-making to determine the ranking of risks in the supply chain.
Uca et al. (2017)	They used structural equation modeling to clarify the relationship between trust in the supply chain and firm performance through supply chain collaboration and collaborative advantage.
A. Alsobhi et al. (2018)	They proposed a mathematical model to minimize the total costs including damage costs, shipping costs, and packaging cost in the supply chain.

By reviewing the literature, it can be concluded that there are few papers that have investigated supply chain damages in FMCG industries by using decision-making tools such as ANP. Therefore, this paper contributes to the FMCG supply chain by classifying important damages based on experts' opinions.

Firstly, damages are divided into four clusters of supply, production, distribution, and support. Table 2 presents a list of supply chain important damages mentioned by researchers based on the literature review.

Tab. 2. The most important identified damages

Cluster	damages	references
Supply	Product design	[46]
	Planning	[28],[43]
	Supplier responsiveness	[34],[29]
	Degree of differentiation among suppliers	[34], [29]
	Number of suppliers	[34],[29]
	Supplier innovation	[34],[29]
	Forecasting processes	[31]
	Supply performance	[34], [29], [38], [39], and [47]
	Financial aspect	[34], [29], and [38]
	Material ordering	[38]
	Inventory	[31] and [38]
Production	Production process disruption	[39], [38], [48] and [46]

	Production quality	[40] and [38]
	Demand change	[38],[39],[43],[49] and[4]
Distribution	Competition	[36]
	Changing the market taste	[23],[38],[16] and [4]
	Bullwhip effect	[38]
	Inconsistency	[30]
	Logistics	[26],[35],[38],[3], [39] and [46]
Support	Distribution	[38], [43],[45] and [46]
	Information	[39]
	Environmental	[39],[40],[41] and [42]

3. Research Methodology

3-1. Subject

This study aimed to identify and to rank supply chain damages using a scientific tool such as the analytic network process (ANP) in an FMCG company. The case company is consumer goods producers, and most of its activities include packaging and distributing food supplied by a variety of suppliers. The company provides a variety of food products with several brands. Launching new products and continuous improvement activities are the most important objectives of this company. The FMCG industries having a network of related organizations that cooperate with each other to control, manage, and improve the flow of materials and information from suppliers to consumers face greater damage. In this regard, the identification and prioritization of supply chain damages ensure the best decision-making.

3-2. Instrument development

To extract the most important supply chain damages, Delphi method was used. Firstly, Delphi questionnaire was designed based on Table1, and a five-point Likert scale includes strongly agree (5), agree (4), neutral (3), disagree (2), and strongly disagree (1). Apre-test was performed with three experts to improve damages content. The minor suggestions applied to improve questionnaire and the final questionnaire was distributed to 20 experts. The experts were the senior and middle managers of the studied company and were asked to confirm or reject identified damages into four clusters including supply, production, distribution, and support. The experts were professional in the supply chain and the identified damage concepts. Score 4 (agree) was selected as a threshold to select important damages. The average score of damages in four clusters is according to Table3. According to the expert opinions, 13 factors were confirmed as supply chain damages in four clusters.

Tab. 3. The confirmed supply chain damages in the studied company.

Cluster	Damages	Average score
A Supply	Supply performance damages	4.15
	Financial damages	4.08
	Material ordering damages	5
B Production	Inventory damages	4.54
	production process disruption damages	4.08
	Production quality damages	4.77
C Distribution	Demand change damages	4.38
	Competition damages	5
	Changing the market taste	5
	Bullwhip effect damages	4
	Inconsistency damages	4.15
D Support	Logistics damages	4.23
	distribution damages	4.15

3-3.Content validity

Content validity implies whether the data collection method or tool is as good as the content that should be measured. In other words, content validity considers the ability of a data collection tool or method to cover the entire content of a particular construct. Lawshe (1975) invented a highly functional approach to measure content validity [50]. This method measures the degree of agreement between evaluators on the appropriateness or relevance of a particular item. According to Lawshe (1975), if more than half of the evaluators consider that an item is useful to measure the construct, it certainly has content validity. The content validity ratio (CVR) was calculated according to Equation (1) for each defined damage:

$$CVR = \frac{n_e - \frac{N}{2}}{\frac{N}{2}} \quad (1)$$

CVR: Content validity ratio

ne: The number of evaluators who states that the item is
substantial or useful

N: The total number of evaluators

The CVR threshold for accepting the validity of defined damages was 0.49. A number of 20 Factor Identification Inventories were completed by experts. The results of calculated CVR according to experts' opinions are presented in Table 4.

Tab. 4. Content validity ratio according to the number of valuators

Damages	Number of experts agree with damage	Calculated CVR	Acceptable CVR
Supply performance damages	18	0.8	0.49
Financial damages	15	0.5	0.49
Material ordering damages	17	0.7	0.49
Inventory damages	18	0.8	0.49
production process disruption damages	16	0.6	0.49
Production quality damages	20	1	0.49
Demand change damages	16	0.6	0.49
Competition damages	17	0.7	0.49
Changing the market taste	18	0.8	0.49
Bullwhip effect damages	17	0.7	0.49
Inconsistency damages	20	1	0.49
Logistics damages	16	0.6	0.49
distribution damages	17	0.7	0.49

According to the results, all of the above-mentioned damages were acceptable. In the next step, the ANP method was used to calculate the weight of defined damages. Given the fact that all damages are interconnected in the supply chain, the ANP technique was used.

3-4. Determining the weight of the damages

The pairwise comparison table was formed by using the relationship network of factors among the clusters according to Figure 1.

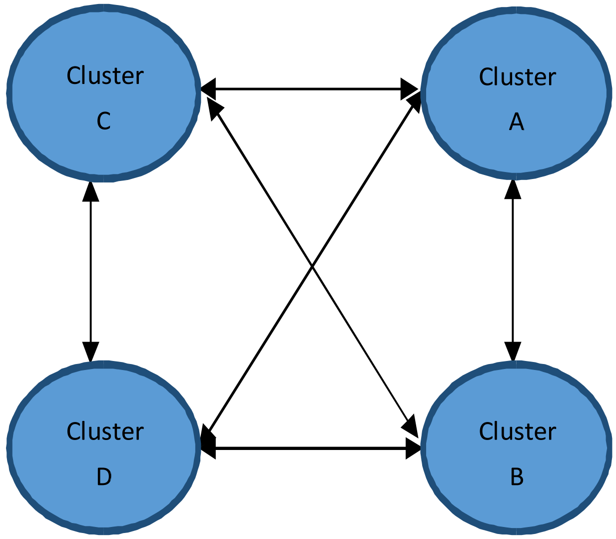

Fig. 1. The pairwise comparisons of clusters

According to the defined damages, ANP questionnaire was designed and distributed between experts. Based on the gathered data, the pairwise comparison matrix was formed. The examples of calculating pairwise comparison matrix for cluster "supply" include supply performance, financial, material ordering, and inventory; for cluster "support", they include inconsistency, logistics, and distribution, as shown according to Tables 5, 6, 7, and 8. For each matrix, the inconsistency ratio was calculated.

Tab. 5. The first matrix

Supply performance	inconsistency	logistics	distribution	
inconsistency	1	$\frac{1}{3}$	4	0.27
Logistics	3	1	6	0.644
distribution	$\frac{1}{4}$	$\frac{1}{6}$	1	0.851

IR=0.047

Tab. 6. The second matrix

financial	inconsistency	logistics	distribution	
inconsistency	1	3	7	0.67
Logistics	$\frac{1}{3}$	1	3	0.24
distribution	$\frac{1}{7}$	$\frac{1}{3}$	1	0.08

IR=0.017

Tab. 7. The third matrix

Material ordering	inconsistency	logistics	distribution	
inconsistency	1	$\frac{1}{2}$	$\frac{1}{3}$	0.169
Logistics	2	1	1	0.387
distribution	3	1	1	0.46

IR=0.01

Tab. 8. The fourth matrix

inventory	inconsistency	logistics	distribution	
inconsistency	1	5	3	0.65
logistics	$\frac{1}{5}$	1	$\frac{1}{2}$	0.12
distribution	$\frac{1}{3}$	2	1	0.23

IR=0.035

In order to calculate the consistency ratio, the Eigenvector techniques were used by Excel software. For example, the consistency ratio of the first matrix is calculated as follows. In the first step, the matrix of Table 5 is multiplied by the weight of each one using "Equation (2)":

AW= λW(2)

$$\begin{bmatrix} 1 & 0.333 & 4 \\ 3 & 1 & 6 \\ 0.25 & 0.166 & 1 \end{bmatrix} * \begin{bmatrix} 0.27 \\ 0.644 \\ 0.851 \end{bmatrix} = \begin{bmatrix} 0.825 \\ 1.965 \\ 0.2595 \end{bmatrix}$$

In the second step, l_{max} was found by using "Equation (3)":

$$l\max = \frac{AW}{W} \quad (3)$$

0.825/0.27=3.055

1.965/0.644=3.0506 0.2595/0.0851=3.049

λmax=3.055

In the third step, the inconsistency index is calculated by using "Equation (4)":

$$II = \frac{\lambda_{max} - n}{n-1} \quad (4)$$

(3.055-3)/2=0.0275

In the last step, the inconsistency ratio was calculated by using "Equation (5)":

$$IR = \frac{II}{IIR} \quad (5)$$

0.0275/0.058=0.047

Due to the consistency of pairwise comparison matrices, a super matrix was formed according to Table A.1 (Appendix A). The calculated normal super matrix was formed according to Table A.2 (Appendix A).

4. Results

The weights of all damages were determined by the consistent super matrix, as shown in TableA.3 (Appendix A). The weight of the supply chain damages was determined, as shown in Table 9. Finally, supply chain damages are ranked according to Table 10.

Tab. 9. Certain weights of damages

Cluster	Damages	Weight
Supply	Supply performance damages	0.102
	Financial damages	0.112
	Material ordering damages	0.132
	Inventory damages	0.133
Production	production process disruption damages	0.125
	Production quality damages	0.140
Distribution	Demand change damages	0.146

	Competition damages	0.179
	Changing the market taste	0.175
	Bullwhip effect damages	0.172
	Inconsistency damages	0.172
Support	Logistics damages	0.209
	distribution damages	0.203

Tab. 10. Ranking of damages

Damages	Ranking
Logistics damages	1
Distribution damages	2
Competition	3
Change in the market taste	4
Bullwhip effect and inconsistency damages	5
Demand change damages	6
Production quality damages	7
Inventory damages	8
Material ordering damages	9
Production process disruption damages	10
Financial damages	11
Supply performance damages	12

5. Conclusion

In today's competitive market, manufacturers need to measure and compare the success of their products and competitors and take logical measures to improve their product position in the eyes of buyers. Any competitor who can provide more value for customers can take a larger share of the market. Therefore, it is necessary to highlight the significant dimensions of the value creation of each product and emphasize the factors that are more important from customers' points of view.

In today's market, because of customer's growing knowledge and the enhancement of the competition between manufacturers, it is required to apply the best particular solutions to manage supply chain and its damages. In this study, by using the experts' opinions, the supply chain damages in the FMCG company were identified, and 13 damages were selected as the most important damages. Using the analytic network analysis (ANP), the weights of damages were determined based on their impact on each other. Based on the obtained results, the most significant supply chain damages were logistics, distribution, competition, and changing market tastes; thus, the company should focus on managing these damages. Logistics damage is the most important item that implies the management of the flow of goods, information, or any other source, such as humans, between the place of production or the place of inventory up to the point of consumption to meet the consumption needs and the identified damage, which may be the lack of coordination between the sales and distribution unit or the error in information reports or fraction of goods in stock having the most damage.

The results of this study support the results of previous studies. In this section, the major damages are mentioned. Shah (2009) mentioned that FMCG industries had complex distributers network and faced intense competition ([51]). She believed that "FMCG sectors worked with a very complex distribution system and comprised multiple layers of numerous small retailers between company and consumers" [51]. These damages include pack sizes, transportation cost, handling and packing cost [51], discounts, distribution channels, and price. The third key damage is competition. Because of intense competition, usually, retailers request high margin to offer better deals to consumers; therefore, usually, FMCG companies consider promotions and discounts for their distribution channels such as wholesalers and retailers;

however, consumers are not considered to use these added values [51]. High consumption quantity of FMCG products in different markets causes complex controlling on distribution performance for FMCG companies.

A number of risks and miscalculations, such as distribution in the wrong location, failure to load at the right time, and conflicting information from the sales unit, result in customers' having low or high order and their unsatisfaction, which is a great damage. Because of the fast-changing tastes of consumers, it is required to conduct continuous marketing research analysis for competing in the market and increasing market share; otherwise, it can divert the company in the wrong direction. To gain more market share, it needs to launch new products in the competitive FMCG market. Response to new favorite tastes is a key factor to create competitive advantage [1]. Therefore, changing the market taste can be answered by an innovative agile supply chain. Competition at high costs for advertising and avoiding a cost-cutting approach can put the organization at risk. These damages indicate that logistics and distribution damages have the most impact on the supply chain. Since food chain management as in the FMCG industry faces complexity and difficulty, identifying and reducing the damages will be important. If the existing damages are eliminated or removed, the efficiency and profitability of the supply chain will increase. Some studies have focused on key factors that affect the performance of the FMCG supply chain. Some research studies considered bullwhip effect on the FMCG sector as an important challenge in FMCG supply chains and suggested models and solutions to reduce it ([52] and [53]). This study discovers all damages that can affect FMCG supply chain particularly. Identifying and ranking supply chain damages are important for managers in order to cover risks. Therefore, the proposed approach helps managers in FMCG industries to apply suitable solutions to supply chain problems such as risks and damages. Integrating strategic management and supply chain management and focusing on fulfilling customer real needs will be useful to cover damages efficiently [54]. The results of this study will be a reference for FMCG companies in similar situations. Exploring the causes of defined damages can be investigated in future research studies.

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Tab. A. 1. Super matrix

	A1	A2	A3	A4	B1	B2	C1	C2	C3	C4	D1	D2	D3
A1	0.174	0.22	0.24	0.24	0.370	0.12	0.12	0.20	0.16	0.10	0.103	0.245	0.168
A2	0.48	0.22	0.20	0.10	0.25	0.05	0.043	0.36	0.24	0.18	0.068	0.30	0.263
A3	0.10	0.059	0.08	0.10	0.10	0.25	0.26	0.13	0.10	0.05	0.23	0.10	0.20
A4	0.133	0.26	0.15	0.04	0.06	0.27	0.36	0.07	0.09	0.45	0.99	0.04	0.16
B1	0.10	0.24	0.30	0.30	0.20	0.30	0.20	0.20	0.40	0.32	0.30	0.73	0.20
B2	0.47	0.37	0.58	0.33	0.38	0.36	0.33	0.71	0.73	0.10	0.73	0.65	0.06
C1	0.43	0.38	0.32	0.56	0.32	0.18	0.38	0.14	0.08	0.67	0.08	0.07	0.26
C2	0.09	0.24	0.08	0.09	0.28	0.45	0.28	0.14	0.19	0.22	0.18	0.27	0.67
C3	0.61	0.71	0.41	0.50	0.28	0.50	0.25	0.70	0.40	0.39	0.65	0.42	0.50
C4	0.39	0.29	0.59	0.50	0.72	0.50	0.75	0.30	0.60	0.61	0.35	0.58	0.50
D1	0.27	0.67	0.16	0.65	0.26	0.586	0.44	0.49	0.65	0.27	0.63	0.58	0.33
D2	0.644	0.24	0.387	0.12	0.65	0.22	0.45	0.343	0.266	0.649	0.258	0.322	0.59
D3	0.08	0.08	0.46	0.23	0.07	0.18	0.11	0.15	0.08	0.072	0.10	0.08	0.07
Sum	4	4	4	4	4	4	4	4	4	4	4	4	4

Tab. A. 2. Normalized super matrix

	A1	A2	A3	A4	B1	B2	C1	C2	C3	C4	D1	D2	D3
A1	0.044	0.055	0.060	0.061	0.093	0.030	0.032	0.050	0.040	0.025	0.026	0.061	0.042
A2	0.122	0.055	0.052	0.078	0.064	0.013	0.011	0.091	0.061	0.047	0.017	0.075	0.066
A3	0.027	0.015	0.022	0.025	0.027	0.063	0.067	0.034	0.026	0.014	0058	0.025	0.050
A4	0.033	0.065	0.040	0.012	0.016	0.068	0.090	0.020	0.023	0.113	0.075	0.012	0.042
B1	0.025	0.060	0.075	0.075	0.050	0.075	0.050	0.055	0.100	0.051	0.075	0.077	0.050
B2	0.118	0.094	0.147	0.083	0.096	0.090	0.083	0.178	0.183	0.025	0.183	0.163	0.016
C1	0.109	0.095	0.081	0.142	0.082	0.047	0.096	0.036	0.020	0.169	0.020	0.018	0.066
C2	0.024	0.062	0.022	0.024	0.072	0.113	0.071	0.036	0.048	0.057	0.047	0.070	0.168
C3	0.153	0.178	0.103	0.125	0.070	0.125	0.063	0.175	0.100	0.098	0.163	0.105	0.125
C4	0.098	0.073	0.148	0.125	0.180	0.125	0.188	0.075	0.150	0.153	0.088	0.145	0.125
D1	0.068	0.168	0.042	0.163	0.066	0.147	0.110	0.124	0.163	0.070	0.159	0.147	0.084
D2	0.161	0.060	0.097	0.30	0.165	0.057	0.113	0.086	0.067	0.162	0.065	0.081	0.148
D3	0.021	0.022	0.115	0.058	0.020	0.047	0.028	0.040	0.020	0.018	0.026	0.022	0.019
Sum	1	1	1	1	1	1	1	1	1	1	1	1	1

Tab. A. 3. Consistent super matrix

	A1	A2	A3	A4	B1	B2	C1	C2	C3	C4	D1	D2	D3
A1	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102
A2	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112	0.112
A3	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132
A4	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133
B1	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
B2	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
C1	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146
C2	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179
C3	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
C4	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172
D1	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172
D2	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209
D3	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203
Sum	1	1	1	1	1	1	1	1	1	1	1	1	1

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