Trends in Life Sciences
An International Peer-reviewed Journal
www.sciencejournal.in

IDENTIFICATION AND PRIORITIZATION OF SUPPLY CHAIN AGILITY ENABLERS USING FUZZY ANP TECHNIQUE; CASE STUDY: DAIRY INDUSTRY

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ABSTRACT
Supply chain needs a tool to be able to overcome the environmental challenges to survive in the dynamic and changing markets. Agility is such a tool. Several key factors have been identified so far as the enablers of agility. In this research, initially with a review of agility history, various factors affecting the agility are studied that has been identified by various researchers. Then, the impact of this phenomenon is referred to dairy industry supply chain. Effective criteria and factors were identified through library researches and they were completed by experts. Among the identified factors in creating agility, the most important factor in the dairy industry according to industry experts of Sabah Company was detected using fuzzy Delphi method. DEMATEL technique was used to identify the relationships according to the amount of effectiveness and influence of criteria from each other in real world and fuzzy network analytical process model was used after completing the paired comparison questionnaire from the experts for weighting them, so that appropriate solutions be devised by identifying more important factors in supply chain agility.

KEYWORDS: Agility, Supply Chain, Agile Supply Chain, Agility Enablers, Fuzzy ANP, DEMATEL Technique

INTRODUCTION

One of the concepts or paradigm that became common less than two decades is the concept of agility, which is arose from the needs of new organizations to follow the evolution of the previous approaches, such as craft production, mass production, lean production (Goldman et al., 1995). On the other hand, over the past two decades, supply chain management was stated as one of the most important factors of competition and success in organizations and it has received much attention from researchers and experts in production and operations management (Chopra & Meindl, 2001). Pursuing agility in the supply chain as a hybrid concept has attracted the attention of many leaders and experts and researchers sought to provide new perspectives on the emerging concept. For this purpose, it is necessary to identify the agility enablers in each industry and determine the importance of each factor in creating this phenomenon. Agile supply chain initiatives include: Cooperation with competitors, long-term cooperation with customers and suppliers, levering the effect of substantial resources by networking with other companies, difficult functional conditions that make cooperating inevitable with other companies, alliance counterparts in business, integration with other corporate data on computer systems, giving higher priority to the coalition to penetrate the market (Soaford, 2003).

They could be able to present 15 variables for agility by taking advantage of the literature and also, holding brainstorming sessions. These variables include market sensitivity, speed, accuracy of data, new products introduction, collaborative planning, process integration, the use of IT tools, reduce latency, improve service, minimize cost, customer satisfaction, improving quality, minimizing uncertainty, develop trust and reduce resistance to change (Lin et al. 2006). In such condition, the importance of supply chain becomes more highlighted because such chains can react quickly and effectively to market changes (TIS et al., 1997). Agile supply chains are not only able to react to changes in routine, but also they can respond appropriately to dramatic changes needed in the market for the first time. Therefore, it is believed that agility will be a needed attribute for future competitive pressures of organizations and competitive advantage (Joseph et al., 1999). Nowadays, the dairy industry with its long and numerous value chain can be an effective and efficient industry in each economy. Industry that can be a good solution to solve the macro and micro problems of economic communities by creating economic value added and diverse jobs. Hence, in this study, the dairy industry has been chosen as a case study and agility enablers in this industry will be identified and prioritized using fuzzy Delphi method and fuzzy ANP group.

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Research literature

Supply chain

Increasing competition and entering in global markets has created conditions in which, the condition for the survival of organizations is focusing on customer needs and respond quickly to market changes. It is clear that reducing cost increases the level of customer service, immediately meet customer needs, increase product quality and customer service are the cases which are necessary to remain in the competition for every product and every service. In this regard, in past years a concept called supply chain is formed to reduce costs and increase the quality of products and services for customers by creating coordination between the various sectors involved in the production and distribution of the product or service or in other words the effective management of supply chain (Chaharsooghi and Haideri, 2008). A supply chain directly or indirectly includes all stages of customer demands meet. A supply chain is a network of organizations with a variety of processes and activities that create value in the form of a product or service provided to the final customer. Supply chain is dynamic and includes constant flow of information, products, and capital between the various stages. Different processes are done at each stage of the supply chain and these stages have interaction with each other. The main purpose of a supply chain is to meet the needs of the customer, with the highest possible performance and lowest cost (Chaharsooghi and Haideri, 2008).

The following figure shows the general view of a five-level supply chain (including the final customer as a part of a chain) (Chaharsooghi and Haideri, 2008).

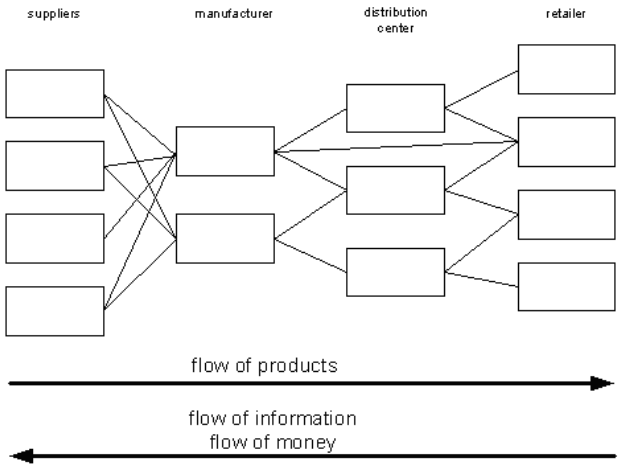

Figure 1. General model of supply chain

Today, the competition is not between the companies, it is between the supply chains (Christopher, 2000). The main purpose of each supply chain is to maximize the total created value. The success criteria for a supply chain should be measured by the total profit chain not a specific level of chain, because attention to a part of chain not only does not create an obligation to maximize profit chain, but also reduces the profitability of the entire supply chain (Kopra and Mindel, 2006).

Agility

Despite many definitions of the word agility, none of them are opposite or violate to each other. These definitions generally show the idea of "speed and change in the business environment". But, according to the new discussion of agility, there is not a general definition which be approved for everyone. According to Sharifi and Zhang (1999), agility means the ability of an organization to feel, perceive and predict changes in the business environment. Such an organization must be able to detect the environmental changes and consider them as agents of growth and prosperity. In another study, they define agility as the ability to cope with unexpected challenges to counter the threat of sudden business environment and taking advantage and benefit from the changes as opportunities for growth and advancement. Brian Maskel (2001) defines agility as the ability to prosperity in the environment with constant and unpredictable changes. In this regard, organizations should not be afraid of changes in their working environment and to avoid them; but also they should imagine the change as an opportunity to gain a competitive advantage in the marketplace.

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Table 1. Chain agility criteria

Criteria	Sub-Criteria	Criteria	Sub-Criteria
Market dimension	quickly and flexibly respond to changes in market requirements	Quality dimension	High quality of the whole lifecycle of products
	New Product Introduction		Substantial value-added products
	Customer-oriented innovation		effective and efficient basic design
	Customer Satisfaction		Shorter lifecycle in development
	Flexibility	Participation dimension	Trust-based relations with customers and suppliers
	Delivery speed		rapid development of effective partnerships in line with the organization's goals
	Delivery performance		Long-term relationships based on loyalty with customers
	Quick access to information related to demand		Close relationships with suppliers
	Virtual Communications		There are no organizational and class walls
	Customer-oriented criteria	Change dimension	Culture change
	Customer-oriented service		Continuous improvement
	Finished products and ready to use for individual customers (non-organizational)	Training dimension	Continuous training and development
	Advantage of opportunities to increase customer value		Learning organization
	Maintain and grow relationships with customers		Flexible and multi-skilled staff
	Products with significant added value for customers		Quick Update workforce skills
	Rapid introduction and identification of new products	Welfare and Social Services dimension	Staff Satisfaction
	Market intelligence	Continuity and perform dimension	Concurrent execution of various activities
	Lowest price		Continuity and perform in organizations
	Legal and contractual conditions		Ease of access to information for staff
	Reliability of delivery	Competence dimension	Mental refutation of Job
	Focus on core competencies development through excellence in processes		Competence and capability of multiple concurrent partnerships
Team building dimension	Decentralized decision-making	Technology dimension	Full knowledge of technology changes
	Empowerment and delegation of authority to work in teams		Effective leadership in the use of available technology
	Multitasking teams		Technologies that facilitate the knowledge and skills of staff
	Working teams at the whole levels of the organization		Flexible manufacturing technology
	Facilitate rapid decision-making		Willingness to share information
			Preference for keeping the information in Archive

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The agility of a company includes the ability to operate profitably operations a competitive environment with continuous, non-predictable and variable opportunities. Agile organizations are flexible to respond to changing market conditions and have a high speed. Agility requires rapid and effective response to market needs. Also, agility includes using the knowledge of marketing and virtual structure for the operation of profitable opportunities in the variable market environment (Naylor et al., 1999). In terms of results and consequences, agility means dynamic, position-oriented and assertive changes that are considered to ensure success in the market share and achieve the mass customers. In other words, agility means the ability of a business unit to grow and survive in a competitive environment that its changes are continuous and unpredictable and require a rapid response to changing markets. Without a doubt, this will be achieved through creating value for required products and services by its customers (Goldzbi et al., 2006). An agile organization is a fast, adaptable and informed business that has the ability to quick adopt in response to unexpected events and unforeseen developments, customer needs, and market opportunities. In such a business, processes and structures are found that facilitate speed, strength and compliance and have coordinate and regular organization that have the ability to achieve competitive performance in a quite dynamic and unpredictable business environment and of course, this environment is not disproportionate to the existing functions (Shariati et al., 2007). In some cases, it is stated that agility theory seeks to review all activities of an organization and redesign those activities by advanced technologies. In this regard, re-engineering of business processes is the mechanism to achieve the organizational agility. According to Soaford et al. (2008) agility is the combination of existing technologies and methods of production system based on the value changes of the manager and staff and also the interaction of technology and innovation management (Soaford et al., 2008).

Agility enablers

Some of the agility enablers have been detected by the conducted studies. In the following table, the main dimensions and these criteria are referred.

MATERIALS AND METHODS

This study is an applied study (Since, it deals with the implementation of a model in a specific industry) and it is descriptive-surveying in term of implementation. In this research, initially data were collected through study resources including books and papers in the related field. Then, this data are refined by experts in the related industry and in the next stage, the refined data are weighted by experts and ranked by fuzzy ANP method.

Analysis method

Fuzzy ANP

The fuzzy sets theory is a new and innovative approach for dealing with imprecise expressions. Using this method, the uncertain situations easily can be entered the problem and the best decision can be made. In this project, Analytical Network Process methods have been developed using fuzzy theory in order to modeling the uncertain conditions. In this method, both input and output of fuzzy ANP method are fuzzy and paired comparisons matrix is completed between the criteria of each row using triangular fuzzy numbers. With this method, parameters' values are obtained in the form of triangular fuzzy numbers and they are calculated in fuzzy. In options (criteria) paired comparisons, the decision-maker (expert) can use triangular fuzzy numbers to determine the degree of preferred options. In classic ANP 1-9 Saaty range is used for paired comparisons. A fuzzy set can be used for triangular fuzzy numbers rather than the logic range of classic ANP 1-9 Saaty range. When the criterion i is compared with the criterion j, respectively, represent the preferences of the i to j, less preferences of i than j, stronger preference for i than j, very strong preference and absolute preference i than j (Semih onüt et al, 2009). In order to assess the preferences of the decision maker, the matrix of paired comparisons is formed using triangular fuzzy numbers (l, m, u). M × n triangular fuzzy numbers matrix can be shown as follows.

In this matrix, a_{ij} shows the importance of the i^{th} row and j^{th} column. If Ã be a paired comparison matrix, it is assumed that the entries of this matrix are inverted than the main diagonal. Thus, $1/a_{ij}$ can be dedicated as a_{ji} element. Therefore, the paired comparison matrix will be as following.

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$$\tilde{A} = \begin{pmatrix} (a_{11}^l, a_{11}^m, a_{11}^u) & (a_{12}^l, a_{12}^m, a_{12}^u) & \cdots & (a_{1n}^l, a_{1n}^m, a_{1n}^u) \\ (a_{21}^l, a_{21}^m, a_{21}^u) & (a_{22}^l, a_{22}^m, a_{22}^u) & \cdots & (a_{2n}^l, a_{2n}^m, a_{2n}^u) \\ \vdots & \vdots & \vdots & \vdots \\ (a_{m1}^l, a_{m1}^m, a_{m1}^u) & (a_{m2}^l, a_{m2}^m, a_{m2}^u) & \cdots & (a_{mn}^l, a_{mn}^m, a_{mn}^u) \end{pmatrix}$$

$$\tilde{A} = \begin{pmatrix} (1,1,1) & (a_{11}^l, a_{11}^m, a_{11}^u) \cdots & (a_{1n}^l, a_{1n}^m, a_{1n}^u) \\ (\frac{1}{a_{11}^u}, \frac{1}{a_{11}^m}, \frac{1}{a_{11}^l}) & (1,1,1) \cdots & (a_{2n}^l, a_{2n}^m, a_{2n}^u) \\ \vdots & \ddots & \vdots \\ (\frac{1}{a_{1n}^u}, \frac{1}{a_{1n}^m}, \frac{1}{a_{1n}^l}) & (\frac{1}{a_{2n}^u}, \frac{1}{a_{2n}^m}, \frac{1}{a_{2n}^l}) \cdots & (1,1,1) \end{pmatrix}$$

In the following table, verbal scales and the corresponding triangular fuzzy number are presented to complete the paired comparison matrix.

Table 2. Fundamental Scale and the related fuzzy numbers

Fundamental Scales		TFN	STFN
1	equal importance	(1,1,1)	(1,1,1)
3	moderate importance of one over another	(1,3,5)	(1/5,1/3,1)
5	strong or essential importance	(3,5,7)	(1/7,1/5,1/3)
7	very strong or demonstrated importance	(5,7,9)	(1/9,1/7,1/5)
9	extreme importance	(7,9,9,)	(1/9,1/9,1/7)

In this stage, fuzzy geometric mean is used to summarize the experts' opinions, which is expressed in form of Ã matrix and paired comparisons.

$$\tilde{z}_{ij} = \left(\sqrt[k]{l_1 \times l_2 \times \ldots \times l_k}, \sqrt[k]{m_1 \times m_2 \times \ldots \times m_k}, \sqrt[k]{u_1 \times u_2 \times \ldots \times u_k}\right)$$

Fuzzy geometric mean = $\tilde{z}_{ij}$

The next stage is estimating the weight criteria and options based on Ã matrix. One of the differences of fuzzy ANP method compared to ANP method is estimating weights. There are several methods to estimate fuzzy weights $\tilde{w}_i$ based on Ã matrix with an approximate value of $\tilde{a}_{ij} \approx \frac{\tilde{w}_i}{\tilde{w}_j}$, so that $\tilde{w}_i = \left(\tilde{w}_i^l, \tilde{w}_i^m, \tilde{w}_i^u\right)$ for i=1, 2, …, n are achieved. Methods such as: Logarithmic least squares method, Buckley geometric mean method, Chang extent analysis, Cheng and Moon distance method, Mikhaeilov fuzzy preference programming method and etc.

The basis for calculation fuzzy weights in this study is based on Chang extent analysis (EA). In EA method, SK values are calculated as follows which are a triangular number for each paired comparisons matrix rows:

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

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

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

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

g represents the row number and i and j respectively, indicate the options and indices. In EA method, after calculating SK, their largeness degree are achieved than each other. In general, if M1 and M2 be two triangular fuzzy numbers, the largeness degree of M1 on M2 is shown by V(M1>M2) and it is defined as follows:

$$\begin{cases} 1, & if\ m_1 \geq m_2 \\ 0, & if\ l_2 \geq u_1 \\ otherwise\ Hgt(M_1 \cap M_2) \end{cases}$$

Also, we have:

Hgt (M1∩M2)= $\dfrac{u_1 - l_2}{(u_1 - l_2) + (m_2 - m_1)}$

The largeness amount of a triangular fuzzy number of k triangular fuzzy number is calculated as follow:
V(M1≥ M2 , …, Mk)=Min[V(M1≥ M2),…, V(M1≥ Mk)]

In EA method, the following must be acted to calculate the weights of the paired comparison matrix:
W′(Xi)=Min{ V(Si ≥ Sk)}, k=1,2,…,n, k≠i
Thus, the vector of weights is as follows:
W′= [W′(c1), W′(c2),…, W′(cn)]^T

Which is the coefficients of the non-normal vector of fuzzy ANP.

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Fuzzy Delphi Method

Implementation stages of fuzzy Delphi method is a combination of Delphi method implementation and analysis of data using fuzzy set theory definitions. Fuzzy Delphi method implementation algorithm is shown in Figure 2.

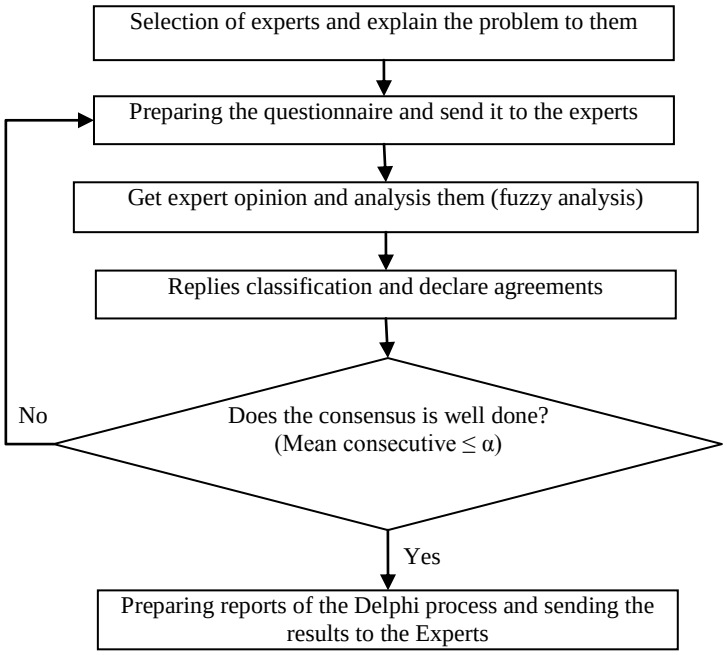

Figure 2. Implementation algorithm of fuzzy Delphi Method (Montazer *et al.*, 2008)

DEMATEL technique

DEMATEL method was introduced for the first time at the Geneva Research Center. This method was used at that time to solve complex problems such as hunger, energy, environmental protection, and etc. DEMATEL method is one of the multi criteria decision making tools based on graph theory which enables us to plan and solve problems; so that maybe we draw several criteria network map in cause/effect group to better understand causal relationships. The final product of DEMATEL process is presenting an image that responders organize their activities based on that and determine it for the relationship between the standards (Lee et al., 2011).

The first stage: Find the mean matrix. Imagine that in this study H is the expert and n is the studied criteria. Each expert is asked to indicate the level of impact and measure the correct rating of 0, 1, 2, 3 and 4 which is based on a zero indicates no impact, 1 low impact, 2 moderate impact, 3 high impact, 4 very high impact. The presented scores by each expert give a non-negative matrix of $X^k = \left[X_{ij}^k\right]_{n\times n}$ with $1 \leq K \leq H$ that respond matrix for each H expert and each element x^k is the presented integer number by xij^k. Diagonal elements of each matrix x^k are developed in zero direction. Then, n×n mean of matrix A can be calculated for all expert opinions by averaging the scores of H as following:

$$[a_{ij}]_{n\times n} = \frac{1}{H}\sum_{k=1}^{K} P_{ij}$$

$A = \left[a_{ij}\right]_{n\times n}$ mean matrix is named direct relationship initial matrix. A indicates the direct initial effects that show a criteria for itself and other criteria. Furthermore, the causal effect between each pair of criteria can be displayed by drawing impact map. Figure 1 is an example of impact network map. Each letter indicates a criteria in the system and each arrow from c to d indicates the impact that c has on d and the impact amount is 4.

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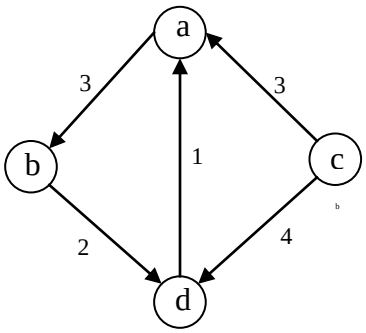

Figure 3. Example of impact map

The second stage: Calculation of the initial matrix for the normalized axis.
Initial matrix D normalized axis is calculated by normalizing mean matrix A:

$$S = \max \sum_{j=1}^{n} a_{ij}$$

$$D = \frac{A}{S}$$

Since, the sum of each row i of matrix A indicates the total impact direction that criteria i gives to other criteria. S indicates the total direct impact with the most impacts on the other criteria. Similarly, the sum of each column j of matrix A represents the total and direct impacts than other measures i. For example, if the sum of first, second, third and fourth row of a 4*4 matrix respectively be 2, 3, 4, and 5 and S value is equal to 5. In the next stage, each element of matrix A is divided on 5 and matrix D is produced.
The third stage: Calculate the total matrix of relations. The sum of the infinite series of direct and indirect impact on the other elements is calculated (with all possible feedback) with a geometric progression, based on existing laws of graphs. Calculating this set requires using $(I-D)^{-1}$. Indirect impacts of elements of the inverse matrix have convergence because the indirect impacts on the chain length of the diagram is continuously decreasing.
The sum of the infinite series of direct and indirect impacts on other elements is shown as follows. Note that:

$$T = D + D^2 + D^3 + \ldots + D^m = D(I - D)^{-1}, \quad m \to \infty$$

In which, 0 is a null matrix n × n and i is definition matrix of n × n. The total relationship matrix T is an n × n matrix and is defined as follows:

$$T = [t_{ij}]_{n \times n}$$

$$R = [r_i]_{n \times 1} = \left(\sum_{j=1}^{n} t_{ij} \right)_{n \times 1}$$

$$D = [d_j]_{1 \times n} = \left(\sum_{i=1}^{n} t_{ij} \right)_{1 \times n}$$

The fourth stage: Define threshold values and draw the network map of relationships. To describe structural relationships between the criteria and maintaining the system complexity with a manageable level, it is necessary to develop the threshold value P to filter out insignificant impact on the matrix T. Only some of the criteria that influence the matrix T is greater than the threshold value should be selected and displayed in the network map of relationships. After the determination of the threshold value, the final impact can be shown on the relationships map.

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RESULTS

Results of the fuzzy Delphi method

A) The first stage of surveys

In this stage, the selected components were sent to members of the expert and their agreement about each of the components were taken and their opinion were gathered.

Table 3. Average views of experts obtained from the first stage

	Components	Triangular fuzzy average(m, α, β)	De-fuzzy average
1	Looking for an opportunity to enhance customer value	(0.13, 0.19, 0.7)	0.68
2	Jointly product development	(0.18, 0.17, 0.48)	0.48
3	Customer-oriented products	(0.05, 0.22, 0.9)	0.85
4	Obtaining the immediate demand data	(0.16, 0.19, 0.63)	0.62
5	Team criteria and objectives	(0.2, 0.2, 0.48)	0.48
6	Senior management commitment to agile actions	(0.14, 0.21, 0.7)	0.68
7	Active updating the combination of processes in the supply chain network	(0.12, 0.2, 0.75)	0.72
8	Infrastructure to encourage innovation by reducing the time	(0.14, 0.21, 0.6)	0.65
9	Rapid introduction of new products	(0.19, 0.03, 0.23)	0.27
10	Maintain and grow customer relationships	(0.12, 0.19, 0.7)	0.68
11	Facilitate quick decisions	(0.08, 0.21, 0.85)	0.81
12	Preference for storing data in archive	(0.16, 0.2, 0.61)	0.60
13	Focus on developing core competencies with process excellence	(0.15, 0.2, 0.65)	0.63
14	Relationships based on trust between customer and supplier	(0.14, 0.21, 0.6)	0.65
15	Virtual communication	(0.19, 0.13, 0.3)	0.31
16	Concurrent execution of activities along the supply chain	(0.2, 0.15, 0.45)	0.46
17	Emphasis on outsourcing	(0.18, 0.18, 0.51)	0.51
18	Access to information throughout the supply chain	(0.17, 0.21, 0.61)	0.60
19	Paperless transactions	(0.18, 0.2, 0.52)	0.52
20	Data associated with the moment sale	(0.13, 0.19, 0.73)	0.71
21	Access to information and knowledge through the Internet	(0.18, 0.2, 0.61)	0.61

As can be seen, the most agreement was with customer-oriented products and the least agreement was with the rapid introduction of new products and virtual communication. After holding face to face consultation with experts and professors and advisors, following corrective actions were taken:

- Two components of the rapid introduction of new products and virtual communication were removed due to gaining the least score in the first stage of fuzzy Delphi method.
- The emphasis on outsourcing and joint product development are deleted according to a studies samples.
- Also, since the two components of the concurrent execution of activities throughout the supply chain and the other components of the criteria and objectives of the team are in the heart of other components, they are removed from the model.

B) The first stage of surveys

In this stage, a second questionnaire was prepared while necessary changes in the components of agility and it was sent to the experts with previous opinions and their difference with the others. After the implementation of the second stage of the surveying, according to the views presented in the first stage and their compression with the results of this stage

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surveying process is stopped, since the difference between the two stages is less than the threshold (1.0, 0). The threshold is calculated from the following equation:

$$s(A_{m2}, A_{m1}) = \left| \frac{1}{3} \left[(a_{m21} + a_{m22} + a_{m23}) - (a_{m11} + a_{m12} + a_{m13}) \right] \right|$$

In the previous equation (a_{m21}, a_{m22}, a_{m23}) indicates the experts' opinion in the second stage (a_{m11}, a_{m12}, a_{m13}) indicates the experts' opinion in the first stage that differences in two stages is shown with $S(A_{m2}, A_{m1})$.

Table 4. Average views of experts obtained from the second stage

	Components	Triangular fuzzy average(m, α, β)	De-fuzzy average
1	Looking for an opportunity to enhance customer value	(0.15, 0.2, 0.68/0)	0.67
2	Customer-oriented products	(0.08, 0.2, 0.85)	0.82
3	Obtaining the immediate demand data	(0.18, 0.2, 0.61)	0.61
4	Senior management commitment to agile actions	(0.13, 0.19, 0.71)	0.69
5	Active updating the combination of processes in the supply chain network	(0.11, 0.21, 0.8)	0.77
6	Infrastructure to encourage innovation by reducing the time	(0.16, 0.21, 0.65)	0.63
7	Maintain and grow customer relationships	(0.14, 0.21, 0.6)	0.65
8	Facilitate quick decisions	(0.13, 0.19, 0.73)	0.71
9	Preference for storing data in archive	(0.16, 0.19, 0.63)	0.62
10	Focus on developing core competencies with process excellence	(0.17, 0.2, 0.65)	0.64
11	Relationships based on trust between customer and supplier	(0.13, 0.2, 0.71)	0.7
12	Access to information throughout the supply chain	(0.17, 0.21, 0.6)	0.59
13	Paperless transactions	(0.18, 0.2, 0.51)	0.51
14	Data associated with the moment sale	(0.14, 0.21, 0.7)	0.68
15	Access to information and knowledge through the Internet	(0.16, 0.2, 0.61)	0.60

The difference between the first and second stages in this case is:

Table 5. Difference between the first and second stages

	Components	De-fuzzy average 1	De-fuzzy average 2	Difference
1	Looking for an opportunity to enhance customer value	0.68	0.67	0.01
2	Customer-oriented products	0.85	0.82	0.03
3	Obtaining the immediate demand data	0.62	0.61	0.01
4	Senior management commitment to agile actions	0.68	0.69	0.01
5	Active updating the combination of processes in the supply chain network	0.72	0.77	0.05
6	Infrastructure to encourage innovation by reducing the time	0.65	0.63	0.02
7	Maintain and grow customer relationships	0.68	0.65	0.03
8	Facilitate quick decisions	0.81	0.71	0.01
9	Preference for storing data in archive	0.60	0.62	0.03
10	Focus on developing core competencies with process excellence	0.63	0.64	0.04
11	Relationships based on trust between customer and supplier	0.65	0.7	0.02
12	Access to information throughout the supply chain	0.60	0.59	0.01
13	Paperless transactions	0.52	0.51	0.01
14	Data associated with the moment sale	0.71	0.68	0.03
15	Access to information and knowledge through the Internet	0.61	0.60	0.01

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According to the above process, the components of looking for an opportunity to enhance customer value, customer-oriented products, obtaining immediate information on demand, Senior management commitment to agile actions, Active updating the combination of processes in the supply chain network, infrastructure to encourage innovation by reducing the time, maintain and grow customer relationships, facilitate quick decisions, preference for storing data in archive, focus on developing core competencies and process excellence, relationships based on trust between customer and supplier, access to information throughout the supply chain, paperless transactions, data associated with the moment sale, access to information and knowledge through the Internet were selected as the final components to design conceptual model of pattern number 1.

According to the results of the fuzzy Delphi method (refining agility enablers), pattern number 1 of the research is presented in Figure 3 that the classification of these factors is in four total criteria.

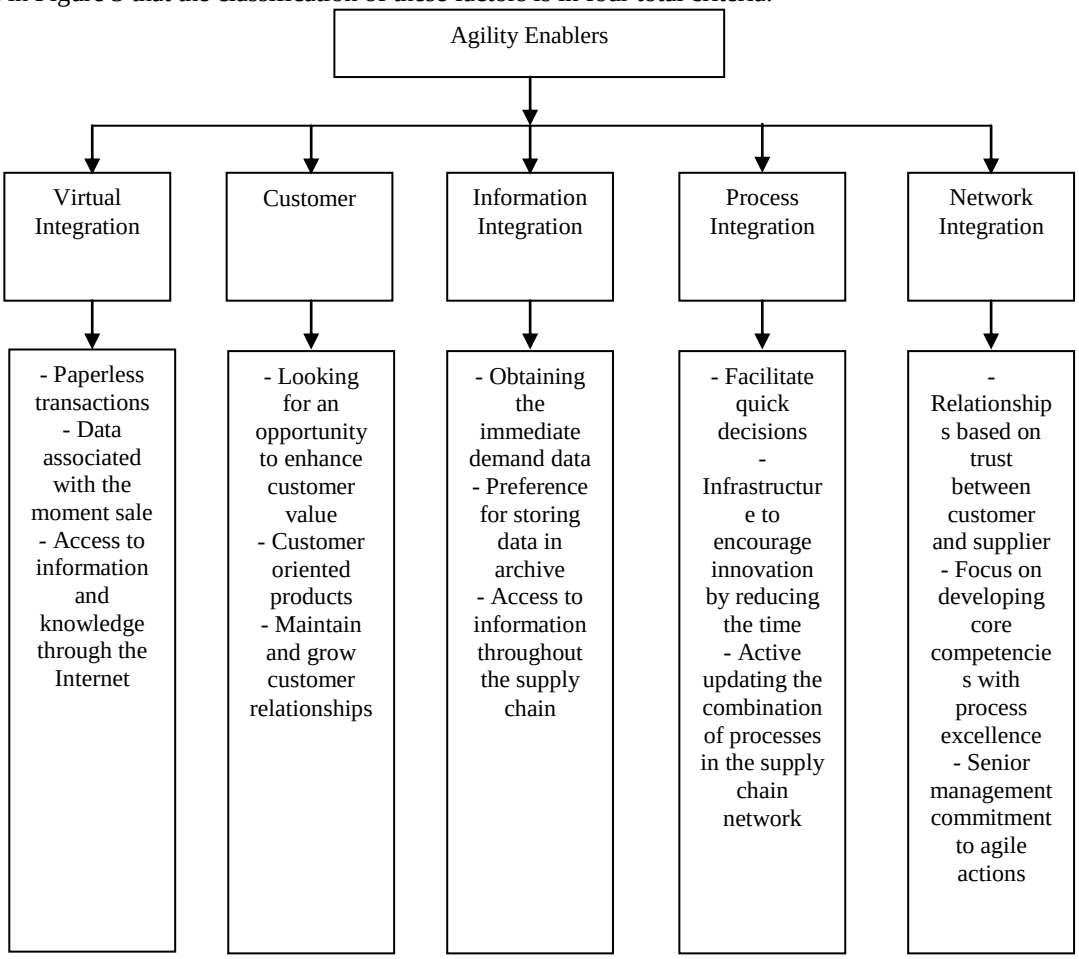

Figure 3. Classification of factors affecting the agility

1.1. Evaluating data correlation using DEMATEL

In order to evaluate 15 criteria presented in Figure 3, symbols and their names were given in the following table:

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Table 6. Sub-criteria titles

	Final Sub-criteria	Abbreviation
1	Looking for an opportunity to enhance customer value	S_1
2	Customer-oriented products	S_2
3	Obtaining the immediate demand data	S_3
4	Senior management commitment to agile actions	S_4
5	Active updating the combination of processes in the supply chain network	S_5
6	Infrastructure to encourage innovation by reducing the time	S_6
7	Maintain and grow customer relationships	S_7
8	Facilitate quick decisions	S_8
9	Preference for storing data in archive	S_9
10	Focus on developing core competencies with process excellence	S_{10}
11	Relationships based on trust between customer and supplier	S_{11}
12	Access to information throughout the supply chain	S_{12}
13	Paperless transactions	S_{13}
14	Data associated with the moment sale	S_{14}
15	Access to information and knowledge through the Internet	S_{15}

Also, 5 values are presented in order to compare the criteria and sub-criteria including no impact (0), low impact (1), medium impact (2), high impact (3) and very high impact (4).

The opinions of 7 experts are used to evaluate the criteria that in this matrix x_{ij} is the opinion of each expert and $x_{ii} = (i = 1,2,3, \dots, n)$ is equal to zero (the main diagonal is zero).

To consider the opinion of all experts according to Formula 1, we calculate their average.

$$z = \frac{x^1 + x^2 + x^3 + \dots + x^p}{p}$$

In this formula, p is the number experts and x^1, x^2, x^p , respectively are the paired comparison matrix expert 1, expert 2, and expert p. Then, we calculate averages of results and then we normalize the calculated matrix. After calculating the normalized matrix, the fuzzy total relation matrix is obtained according to the following formula.

$$T = \lim_{k \to +\infty} (H^1 + H^2 + \cdots + H^k) = H \times (I - H)^{-1}$$

In this equation, i is the unique matrix.

Table 7. Total relations matrix

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}
S_1	0.1	0.12	0.19	0.13	0.11	0.18	0.09	0.08	0.08	0.19	0.26	0.21	0.04	0.07	0.06
S_2	0.09	0.07	0.05	0.13	0.12	0.21	0.1	0.04	0.12	0.09	0.22	0.09	0.03	0.05	0.04
S_3	0.17	0.23	0.07	0.28	0.24	0.29	0.2	0.09	0.14	0.11	0.31	0.11	0.19	0.17	0.16
S_4	0.12	0.11	0.09	0.1	0.19	0.22	0.08	0.19	0.09	0.09	0.14	0.1	0.05	0.07	0.04
S_5	0.14	0.08	0.12	0.12	0.07	0.15	0.11	0.04	0.08	0.11	0.23	0.1	0.05	0.06	0.08
S_6	0.12	0.19	0.09	0.21	0.2	0.13	0.08	0.06	0.19	0.09	0.17	0.13	0.05	0.06	0.04
S_7	0.14	0.14	0.1	0.24	0.09	0.19	0.08	0.09	0.12	0.12	0.26	0.21	0.18	0.17	0.19
S_8	0.14	0.11	0.09	0.25	0.15	0.25	0.1	0.06	0.1	0.19	0.26	0.13	0.17	0.19	0.16
S_9	0.21	0.21	0.1	0.24	0.14	0.26	0.11	0.11	0.08	0.1	0.27	0.11	0.15	0.13	0.17
S_{10}	0.19	0.1	0.08	0.14	0.07	0.12	0.06	0.06	0.07	0.07	0.23	0.14	0.03	0.11	0.07
S_{11}	0.12	0.1	0.1	0.13	0.1	0.15	0.1	0.07	0.07	0.09	0.12	0.19	0.08	0.07	0.04
S_{12}	0.21	0.12	0.1	0.15	0.08	0.15	0.18	0.09	0.1	0.2	0.27	0.12	0.06	0.17	0.13
S_{13}	0.04	0.05	0.03	0.22	0.03	0.23	0.05	0.07	0.03	0.03	0.16	0.1	0.03	0.06	0.03
S_{14}	0.15	0.11	0.03	0.21	0.1	0.22	0.03	0.04	0.19	0.11	0.16	0.04	0.05	0.05	0.09
S_{15}	0.06	0.09	0.07	0.19	0.08	0.12	0.05	0.08	0.04	0.05	0.15	0.09	0.06	0.05	0.03

The next step is to obtain all the rows and columns of the matrix T. We obtain the sum of rows and columns according to the following formulas.

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$$(D)_{n\times 1} = [\sum_{j=1}^{n} T_{ij}]_{n\times 1}$$

$$(R)_{1\times n} = [\sum_{i=1}^{n} T_{ij}]_{1\times n}$$

In which, D and R respectively are $n \times 1$ and $1 \times n$ matrixes.

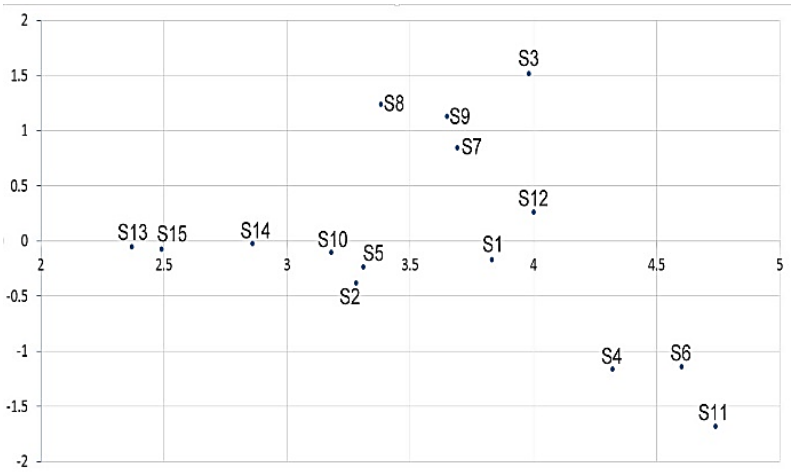
In the next stage, the importance of indices ($D_i + R_i$) and the relation between ($D_i - R_i$) are specified. If $D_i - R_i > 0$, the criteria is effective and if $D_i - R_i < 0$ the criteria is affective. The following table shows $D_i + R_i$ and $D_i - R_i$.

Table 7. The importance and impact of criteria

	$D_i + R_i$	$D_i - R_i$
S_1	3.91	-0.09
S_2	3.28	-0.38
S_3	4.07	1.45
S_4	4.42	-1.06
S_5	3.31	-0.23
S_6	4.68	-1.06
S_7	3.74	0.9
S_8	3.52	1.18
S_9	3.89	0.89
S_{10}	3.11	-0.03
S_{11}	4.64	-1.58
S_{12}	4	0.26
S_{13}	2.38	-0.06
S_{14}	2.89	-0.07
S_{15}	2.54	-0.12

The following figure illustrates the importance and effect of the criteria. The horizontal axis of the diagram shows the importance of the criteria and the vertical axis shows the effectiveness or efficacy of criteria.

Figure 4. Relationship and importance of the criteria



Prioritization using ANP method

In order to implement the model to prioritize the factors effecting agility in the dairy industry supply chain, the inconsistency rate of this matrix was calculated after collecting the paired comparisons matrixes from experts in the industry, which were inconsistent in somewhere. Again, the experts were asked to complete more careful the paired comparisons questionnaires which have inconsistent matrixes. After determining the complete compatibility of

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matrixes, these matrixes were integrated with the geometric mean between 7 experts. Then, the inconsistency rate of the integrated matrixes were calculated which was presented along with integrated paired comparisons matrixes. After ensuring the compatibility of paired comparisons matrixes, the weights of effective components in model were extracted in the firm of matrix with Chang extent method and the calculations of this method for matrix number 1 is given as examples in the following. The calculations of other matrices were not presented due to the high volume of calculations. In the next stage, the final weights of sub-criteria were calculated considering the extracted weights related to criteria and sub-criteria and according to the structure of super matrixes which are shown in the following and on this basis, the agility enablers of the dairy industry supply chain were prioritized.

Table 8. The final weights and rankings of effective factors on the dairy industry supply chain agility

Main Factors	Final Weights	Final Rank	Main Sub-Factors	Final Weights	Final Rank
C_1	0.233	3	S_1	0.011	10
			S_2	0.037	7
			S_3	0.001	14
C_2	0.259	2	S_4	0.087	4
			S_5	0.057	6
			S_6	0.149	3
C_3	0.214	4	S_7	0.002	12
			S_8	0.022	8
			S_9	0.015	9
C_4	0.240	1	S_{10}	0.058	5
			S_{11}	0.347	1
			S_{12}	0.211	2
C_5	0.055	5	S_{13}	0.0002	15
			S_{14}	0.002	13
			S_{15}	0.003	11

DISCUSSION AND CONCLUSION

Based on the findings of this study, which is identifying and classifying the key factors of supply chain agility, the main factors have been identified and prioritized. Macro policies and organizational strategies were developed and necessary programs were determined to achieve specified results in order to strengthen key factors include integration of network, process, information, virtual and customer orientation. According to the obtained results, Sabah Company should reinforce demand for products, customer orientation, and sensitivity to market fluctuations in its supply chain member companies. Undoubtedly, this will not happen without chain alliance member companies. Promotion of commercial and marketing systems and integration of the members may be the most effective solution. Also, efforts in integrating the processes between chain members is one of the essential prerequisites for a more agile supply chain. Among sub-criteria, "customer-oriented products", "maintain and grow customer relationships", and "facilitate quick decisions" were identified as the most influential factors of supply chain agility. Thus, it was suggested that more attention should be paid to production and manufacturing customer-oriented products and customer satisfaction and meet their needs. Also, a comprehensive system of decision was launched in the studied company and necessary training was given about team working and expediting decisions. Launching a comprehensive decision support system and a MIS system can significantly help this issue which causes ease and speed in decision-making and responding to customer needs and consequently, it will strengthen the agility.

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