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The impact of the national standardization system on ranking the supply chain stages improvement

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C H R O N I C L E

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A B S T R A C T

The objective of this study is to measure the performance improvement of supply chain (SC) stages through implementing the national standardization system (NSS) in an innovative way. There are many studies on the positive effects of standardization system on supply chain performance (SCP), but very few studies have measured and prioritized the impact of this system on SCP. This paper introduces a new approach to the performance improvement of each stage of SC through implementing the NSS. First, we use fuzzy analytical hierarchical process method to measure the relative importance of each stage and determine the characteristics of SC. Then, the amount of SC stages improvement after implementing the NSS is determined. Finally, using a combination of results, the stages of SC are ranked according to the effectiveness of NSS implementation. In order to validate the proposed approach, the case analysis of Iran NSS is carried out on broiler SC. The stages of SC are ranked according to the performance improvement through implementing standardization system, subsequently. This approach can be generalized to other standardization systems and SCs.

1. Introduction

During the past few years, there is an increasing trend to integrate all manufacturing processes. Supply chain management as an integrated event for appropriate management of material, information, and financial flows maintains the capability to respond to these conditions (Angerhofer & Angelides, 2000). During the past few years, supply chain management, as one of the key factors in competition and success of organizations, has gained a tremendous attention among the academic and community of manufacturing management and operation (Chopra & Meindl, 2002). There are literally many studies to describe and to analyze the concept of supply chain management (Bowersox et al., 2002; Cooper et al., 1997). Bolstorff and Rosenbaum (2007), for instance, provided an integration of the key business processes from end user through original suppliers, which provides products and information that adds value for customers and stakeholders.

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Information and Communication Technology (ICT) acts as the enabler for controlling, integrating, and coordinating the supply chain plying essential role for improving performance (Russell & Taylor, 2009). Codification as a simple and accurate method for the identification of goods, documents, and firms' properties has been used in business level and SCs. With the help of this system, information flow, especially the product information flow has been facilitated, and all the units have the same fixed impression of each code, which provides the authenticity of plan (Bhakoo & Chan, 2011). For the classification, description, and codification of products and services at various levels, different systems have arisen to fulfill the necessary objectives. One of the most widely used coding systems is the National Standardization System. For instance, industrial production hierarchy packing has been started in North America, America, and Japan respectively since 1937, 1948, and 1949 (Mohr & Russel, 2002). However, some studies are also focused on the positive effects of standardization on Supply Chain Performance (SCP) (Choi et al., 2013; Parreño-Marchante, et al., 2014) but no special approach has proposed to measure and to rank the stages of supply chain based on the effect of implementing national standardization system.

The current study presents an approach to rank different stages of supply chain based on the relative importance of national standardization system. For this purpose, first, the standard factors in the SC broilers are identified; then, in order to measure supply chain performance, the performance criteria at the second level of Supply Chain Operation Reference (SCOR) will be determined. Finally, supply chain is simulated using ED software, and its performance will be measured before and after standardization system implementation. The improvement of chain stages will be determined according to the performance attributes. Using fuzzy AHP methods, the stages of supply chain are weighted. Finally, stages of supply chain are ranked according to the highest impact of national standardization system.

This paper is organized as follow: in section two literature review on supply chain management, supply chain performance, and fuzzy AHP are discussed respectively. In section three, the proposed approach of research is presented. Section 4 presents a case study on the implementation of Iran code on SC broiler and the results are discussed. Final section is dedicated to the conclusion of this study.

2. Literature Review

2.1 Measuring Supply Chain Performance

Performance measurement system is described as a comprehensive set of scales used to quantify the effectiveness and efficiency of an activity (Shepherd & Gunter, 2006). Neely et al. (1995) explained the performance measurement as a quantitative process, which specifies the effectiveness and efficiency of an activity. Later, numerous models have been proposed and expanded by other researchers (Gunasekaran et al., 2001; Kaplan & Norton, 1996; Sallis, 2002). Among the present concepts on supply chain performance, SCOR was model developed by supply chain council (SCC) and it established a useful framework for considering the functional requirements of firms in a supply chain. This model considers supply chain activities as a chain of organizational process associated with each of the firms including five elements of Plan, Source, Make, Deliver, and Returns. Each of these elements is considered as a very important process for inter-organizational supply chain with five measuring criteria including: 1. SC reliability, 2. SC Responsiveness, 3. SC Agility, 4. SC Costs, and 5. SC Asset management (Vlachos, 2014).

2.2. Fuzzy-Analytical Hierarchy Process Method

Analytical Hierarchy Process (AHP) was originally developed by Thomas L. Saati in 1980 and it is a general theory of measurement (Chamodrakas et al., 2010). Every AHP problem consists of three main levels: the first one includes the main objective of the problem; the second and third ones include criteria and options. Elements at given hierarchy levels are compared in pairs by experts to yield their relative preference with respect to each option. According to the main purpose and the option with the highest weight, the overall coefficient weight for each option is chosen. Uncertainty of preference judgments, increases uncertainty in allocated priority of options and makes it difficult to set the degree of agreement in prioritization. Fuzzy AHP method was proposed by Van Laarhoven and Pedrycz (1983) to avoid the hazard functions. This method applies triangular membership functions for pair-wise comparison scale. There are literally various algorithms proposed later by many researchers among which the Chang model has gained wide acceptance (Chang, 1996). This model is utilized in the current study. What follows is a brief description of this method: If we assume two triangular fuzzy numbers: M1= (I1, m1, u1) and M2= (I2, m2, u1) see (Fig. 1):

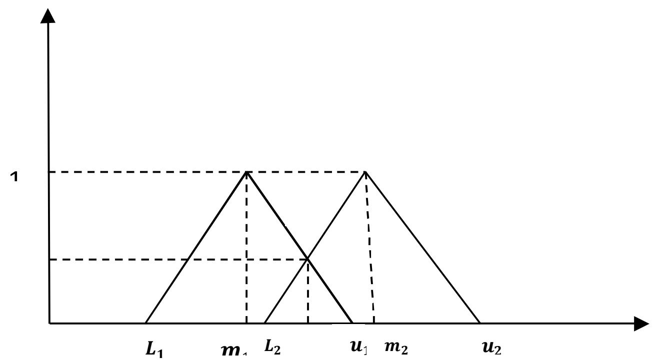

Fig. 1. Triangular fuzzy numbers

The relationships will be illustrated as Eq. (1) - (4):

$$M_1 + M_2 = \left(L_1 + L_2, m_1 + m_2, u_1 + u_2\right), \quad (1)$$

$$M_1.M_2 = \left(L_1L_2, m_1m_2, u_1u_2\right), \quad (2)$$

$$M_1^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{L_1}\right), \quad (3)$$

$$.\,M_2^{-1} = \left(\frac{1}{u_2}, \frac{1}{m_2}, \frac{1}{L_2}\right) \quad (4)$$

Value S_k which itself is a triangular fuzzy number, in this method for each row of pair-wise comparisons matrix is calculated by the Eq. (5):

$$S_K = \sum_{j=1}^{n} M_{Kj} \times \left[\sum_{i=1}^{n}\sum_{j=1}^{n} M_{ij}\right]^{-1}, \quad (5)$$

where *k* denotes the number of row, *i* and *j*, respectively, indicates elements and indices. In this method, after calculating S_k, their largeness degree compared to each other should be estimated. Generally, if M_1 and M_2 are two triangular fuzzy numbers, largeness degree of M_1 and M_2 will be defined as Eq. (6):

$$\begin{aligned} &V(M_2 \le M_1) = 1 && \text{if } M_1 \ge M_2 \\ &V(M_2 \le M_1) = hgt(M_1 \cap M_2) && \text{otherwise} \end{aligned} \quad (6)$$

where: $hgt(M_1 \cap M_2) = \frac{u_1 - L_2}{(u_1 - L_2) + (m_2 - m_1)}$

Largeness degree of a triangular fuzzy number from k other triangular fuzzy numbers is obtained as Eq. (7):

$$V\left(M_1 \geq M_2,\ldots,M_K\right) = V\left(\;\right) \text{ and } \ldots \text{ and } V.\left(M_1 \geq M_K\right) \tag{7}$$

In addition, indices weight in pair-wise comparisons matrix are estimated as Eq. (8):

$$W'\left(X_i\right) = \min\left\{V\left(S_i \geq S_K\right)\right\} \qquad k = 1,2,\ \ldots\ ,n \quad ,\ k \neq i \tag{8}$$

Finally, weight indices vectors will be as Eq. (9):

$$W' = \left[W'\left(X_i\right), W'\left(X_i\right), \ldots, W'\left(X_i\right)\right]^t . \tag{9}$$

3. Research methodology

Implementing National Standardization System causes information integration in the supply chain. Information integration influences effective factors in various stages of the chain and improves the performance of the chain. The performance of each of the stages and the whole chain is improved, which is measurable by choosing SCOR criteria and comparing the performance of the chain before and after implementation of national standardization system. After the experts determine the weights of the criteria, the average improvement of features are calculated and compared. What follows, is an explanation of the main steps of the proposed approach illustrated in (Fig. 2):

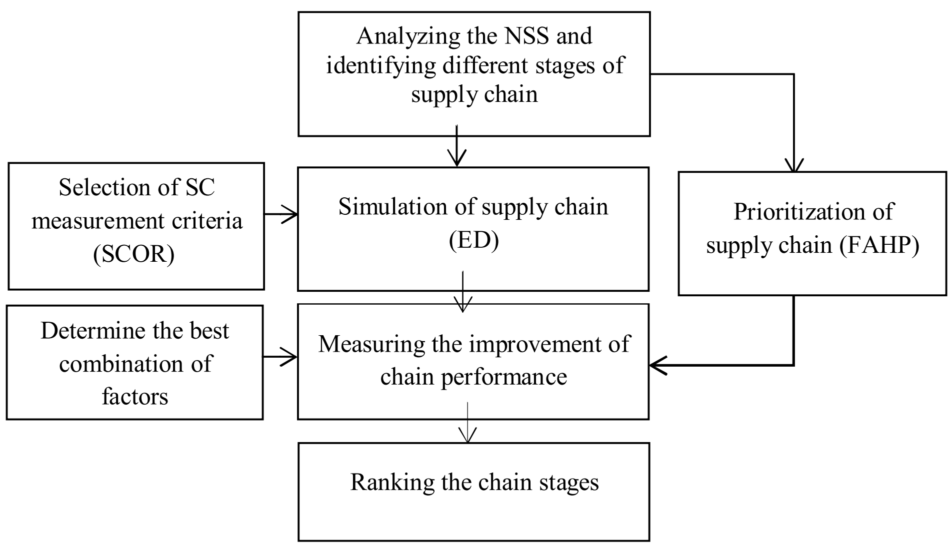

Fig. 2. The steps of research approach

Step 1) Identifying NSS and supply chain stages

This step consists of three phases as follows:

Phase 1. In this phase, NSS that is implemented to fulfill the goals of various groups of customers and stockholders is explained.

Phase 2. A specific supply chain is selected and its stages and processes are fully identified. The factors that can standardize through implementing NSS are identified as well.

Phase 3. Implementation of NSS integrates information, hence causes the best condition in information and factors. Therefore, the optimal combination of factors and chain parameters in standard situation is defined according to each stage.

Step 2. Measuring the Chain Performance Improvement

For measuring the SCP, selecting proper criteria is required. In the present study, SCOR process model is used. In order to determine the SCP in standard mode, measuring the criteria in the best combination factor is needed. The processes related to each of the chain stages based on the SCOR criteria are simulated by Enterprise Dynamics (ED) software. Supply chain performance both before and after implementation of the NSS is measured by the simulation model. The difference in performance is pertaining to the NSS. The value of changes made in SCOR criteria is classified in five SCP attributes and reported as the final approach.

Step 3. Prioritization of the chain stages

Fuzzy AHP method is utilized to prioritize the supply chain stages. For this, initially hierarchical relationships of performance characteristics and the supply chain stages are arranged and illustrated. Then, ranking the supply chain through pair-wise comparisons based on experts is utilized.

Step 4. Measuring and ranking the improvement of supply chain stages

Finally, with the merging the results of the second and third steps, improvement rate of each of the supply chain stages are measured and ranked according to the highest impact of the national standardization system.

4. Case study

In order to validate the current study approach, a case study of implementing Iran national standardization system (Iran code) has been performed on broiler SC. Furthermore, the steps of this study are explained in accordance with the proposed approach.

Step 1. Understanding the National standardization System and stages of supply chain

Phase 1. Iran code is the NSS of this study. It is an experimental system based on scientific principles of classification and description of goods and services in order to fulfill national needs. This system enables producers and suppliers to identify, classify, and codify the goods and services (Ahmadabadi et al., 2013).

Phase 2. The broiler SC has been investigated in this study. This chain consists of grandparent production, parent production, broiler production and slaughterhouse. By studying the different stages, the factors and parameters of broiler supply chain parameters are identified.

Phase 3. Optimum combination of factors and levels of the broiler SC parameters was carried out under standard conditions. The combination for different stages of supply chain is shown in Table 1:

Table 1
The standard condition of factors

Stage	Factor					Parameter					Desirability
	1	2	3	4	5	A	B	C	D	E	
1	-1	.92	1	.92	1	3.51	185.9	6.49	15.6	43.4	.92
2	.97	.99	1	1	1	3.85	144.8	6.9	12.4	43.99	.87
3	-	1	1	1	1	49.92	2.15	9.44	-	-	.87
4	-	-	-	1	-1	.799	-	-	-	-	.82

Step 2. Simulation and measurement of the SC performance improvement

With respect to the objectives of the current study, SCOR process model second level criteria were used to measure supply chain performance. Jalalvand et al. (2011) elicited these criteria for the broiler SC that have been applied in this research. In this study, the simulation method is used to measure the degree of implementing standardization system efficiency on SC stages. For this purpose, the technical knowledge of broiler SC was simulated by ED software. The advantage of simulation in comparison to other methods is the possibility of consolidation of impressive variables and elimination of their effects. Just the effect of standardization variable is measured.

At first, the parameters values in the average situation of factors entered the simulated SC model. By running model, the values of supply chain performance criteria before implementing the national standardization system have been obtained. Then, the values of parameters related to the best combination factors entered the simulated model. The new results indicate the chain performance in standard mode. The difference between these two performances is the outcome of implementing NSS on broiler SC. The degree of improvement due to implementing national standardization system on broiler SC in accordance with the criteria and five performance attributes based on SCOR model is presented in Table 2:

Table 2
Performance improvement of supply characteristics

Chain performance attribute	Performance criterion	Percentage of performance improvement			
		1	2	3	4
Chain reliability	Perfect order fulfillment	4	7.7	10.3	22.7
	Yield	5	5	15	3
	Percentage of returned orders	10	11	8	20
	Percentage of returned orders for reconstruction	5	15	15	15
Chain responsiveness	Cycle time (plan, make, deliver)	41.9	44.7	23.8	24.7
	Order fulfillment cycle time	10.1	21.1	13.7	12.5
Chain agility	High level of compliance (make and deliver)	40	30	20	30
	low level of compliance (make and deliver)	50	60	40	50
	High level of flexibility (make and deliver)	29	30	38	30
Chain costs	Costs	8	11	12	63
	Environmental compliance cost	60	17	25	29
	Product acquisition costs	43	38	32	45
	Cost of sold goods	32	40	94	50
	Product storage costs	0	0	0	33
	Product inventory days	0	0	0	50
	Order costs Management	40	40	35	40
Chain asset management	Return on SC fixed assets	45	34	32	37
	Return on working capital	32	45	37	33
	Cash-to-cash cycle time	7	46	59	54
	Raw material inventory days	50	50	50	67
	Semi-finished product inventory days	0	100	67	70

Step 3. Prioritization of the chain stages

This prioritization is conducted by fuzzy AHP method. According to the first step of this method, the hierarchical structure of functional characteristics and chain stages are illustrated in (Fig. 3):

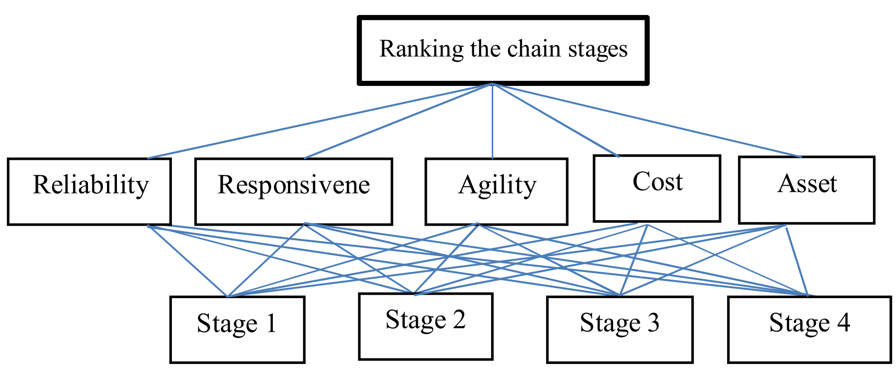

Fig. 3. Hierarchy chart

Subsequently, in the first level, pair-wise comparisons between characteristics of broiler supply chain have been conducted by 25 experts. Table 3 displays the priority of supply chain characteristics and their weights.

Table 3
The weights of performance attributes of broiler supply chain

Attribute	Reliability	Responsiveness	Agility	Cost	Asset management	Weight
Reliability	-	4	.33	.2	2	.1393
Responsiveness		-	2	.25	.33	.0836
Agility	3		-	.2	.5	.1123
Cost	5	4	5	-	3	.4988
Asset management		3	2		-	.1664

In the second level, ranking the stages of chain in comparison to each of the attributed has been conducted. The results of pair-wise comparisons and final matrix of weights for stages are shown in Table 4 as follows,

Table 4
Prioritization of the chain stages

stage	reliability	responsiveness	agility	cost	Asset management	Final stages weight
1	0.5859	0.5995	0.592	0.5976	0.5888	0.5943
2	0.2653	0.2586	0.259	0.2557	0.2645	0.2593
3	0.0846	0.0828	0.121	0.105	0.0885	0.0994
4	0.0896	0.0673	0.064	0.0591	0.0921	0.0701

Step 4. Measuring and ranking the improvement of supply chain stages

In the last level, the results of measuring the improvement of broiler SC stages performance of Table 3 and their prioritization in Table 4 have been combined. Ranking the improvement of broiler SC stages performance resulting from Iran NSS implementation, the last result of this study, is displayed in Table 5 as follows,

Table 5
Ranking the improvement of supply chain stages

Description	Stage 1	Stage 2	Stage 4	Stage 5
Performance improvement (percent)	3.81	1.77	0.74	0.76
Ranking	1	2	4	3

5. Conclusion

Although, standardization systems may substantially improve the performance of the SCs, few studies have been conducted to measure this positive effect and the aim of the present study was to offer a new approach. After analyzing the previous works, a new approach has been presented in which the amount of performance improvement on a broiler SC after implementing NSS of Iran has been measured based on the standards of the SCOR model, and different stages of supply chain have been ranked according to improvement effect. In the procedure of the study, first, standardization system and supply chain processes have been studied and the factors capable of being standardized have been determined. Then, the optimal combination of the factors and values of parameters in the standard case have been determined. Using simulation, the values of chain performance criteria before and after implementing NSS have been obtained, and the degree of performance improvement was measured. In addition, the characteristics and stages of supply chain were prioritized using fuzzy AHP method. The results of measuring the performance improvement and prioritizing the chain stages were combined with each other. Finally, the supply chain stages were ranked based on the highest affectivity. The results of the case study have indicated that implementation of Iran national standardization system maintains a positive effect on the all stages of broiler supply chain. However, the amount of affectivity was not equal in all stages, so that the first and third stages had the highest and lowest improvement resulting from NSS implementation, respectively.

The proposed approach of the present study can be generalized to other NSSs and chains. It is recommended that further research be undertaken on the independence of performance improvements of the chain stages in order to measuring the improvements in the field of activity in industrial and national levels.

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