Identification and Assessment of Supply and Product Risks in Logistics of Advanced Products

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Abstract

In order to maintain the competitive advantage of advanced industries, the supply outsourcing has provided a part of the requirements of research and manufacture, logistics and supply chain with high sensitivity and complexity. In these industries, the logistics in a broader sense includes the role of the supply chain to prepare and manufacture a product from the phase of the raw materials supply to the distribution and delivery of the final product to the customers and its support. There are many factors, e.g. political concerns, technological alterations, regional threats, customers' demands, strategic objectives, financial instability and natural disasters, which have increased the uncertainties and the logistics risks. The management of such risks is essential to reduce the vulnerability of the logistics members. Thereby, the logistics risks should be identified, evaluated and ranked. The present study applies a comprehensive multi-attribute decision-making model called the taxonomic analysis in order to identify and assess the supply and product risks in the logistics, therefore one of the manufacture industries of the advanced products have been studied. In this respect, the logistics have been introduced in this industry and the literature is reviewed and the experts' notion on 44 risks of the supply and product, and 16 assessment attribute have been identified and then a statistics population of 30 experts in the relevant sections, as their answers were obtained via the questionnaire. The identified risks are assessed and ranked by taxonomic method. The results showed that the risk of "monetary policy of upstream entities" as the most important factor and then the "environmental risk (rules, governmental policies, taxation, and economic developments)" and "poor quality of raw materials used by contractor" have highest weight and significance in this model.

Keywords: logistics, logistics management, logistics risk management, multi-attribute decision-making, taxonomic analysis technique.

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1. Introduction

Nowadays, due to the aditem of the customer orientation strategy by the organizations and in order to increase the competitiveness and survival, the production systems have found tendency to produce upon the due orders and the approaches, in which they can have more impact on the critical success factors, e.g. increasing production speed, reduction of waste, improved reliability for on-time delivery, reducing production costs, etc.

Most of the manufacturing costs comprise of the purchase and supply of the raw materials and the spare parts, as the main cost of any product.Thus the supply and logistics sector may play a key role in the efficiency and effectiveness of a manufacture organization and it has a direct impact on the cost reduction, profitability and flexibility (Zsidisin & Ritchie, 2008). The consequence of the significance of the administration of the various supply sectors of the organizations as well as the delivery and after-sales service sectors are manupulated to improve the productivity of the organizations, by which the logistics and supply chain management theories have emerged .

In the advanced goods-manufacture industries, the raw material supply cycle is administered by the qualified contractors, while the design and product research sectors are counted as very important additionally. In these industries, the logistics imply the role of the supply chain in a broader sense for preparation and manufacture of a specific product from the supply of the raw materials to the distribution and delivery of the finished products to the customers, whereas the logistics is used in substitution of the supply chain in the current research. Most manufacturers provide the advanced products subject to the potential problems in the path of logistics in order to follow their own logistics management. In regard of the dynamic system of logistics, the interaction of the internal and external factors comprise the complete complex of the procurement process, where many risk factors incur, e.g. political and regional issues, the competitive threats of the world powers, the demand fluctuations of the advanced products by the consumers, the changes in technology, updating products, the financial instability and the natural events that may lead to the increased uncertainty and many risks in the supply chain and thus the industries act to control and manage them and the risk management activities are called ‘logistics’. Therefore, on the one hand the importance of logistics management in manufacturing industries of the advanced products would be effective in the success and survival of organization and on the other hand the hazards and risks due to the dynamic conditions that threaten it, therefore the topic of the logistics risk management in this type of organizations is considered. Risk management involves the identification, evaluation, categorization, and appropriate responsiveness to various risks. Risk assessment is one of the fundamentals of risk management and it aims to measure the risks based on various factors, e.g. impact and probability. When the results of this phase are more accurate, it can be said that the risk management process is performed with the higher degree of reliance. In fact, the purpose of the risk assessment of the logistics is to warn the management team about the potential damages by the internal or external resources. In this regard, the systematic assessment of the logistic risks provides a basis for planning the risk control. The risk management of the logistics field interacts to imply the significance of this topic and many approaches of identification, evaluation, analysis and dealing with the hazards and risks of the logistics could be developed (Wang, 2013).

Risk assessment is a multi-phase decision-making process, in which the risks(items) are assessed and ranked in terms of indicators. In these methods, mainly the experts' opinions on the indicators and the items (risks) are estimated for the definite numbers and if the decision-making environment is totally ambiguous and unknown, the fuzzy data is used to track the opinions.

Multi-attribut decision-making methods, e.g. taxonomy, AHP, TOPSIS, etc. are the mathematical methods with the definite and fuzzy data developed in the risks ranking process.in this process, have been developed up on the definite and fuzzy data of the risks ranking by the interval numbers. Mathematical modeling capabilities suitable bases are experts in numbers.

Interval numbers indicate the indefinite status of the numbers by the modeling capabilities and the computational complexity is less than the fuzzy numbers. Furthermore, if several experts' opinions with the definite notions for the risk assessment is implied, it is possible that the experts model the Interval numbers by the least data removal (Baradaran & Azarnia, 2013). In this paper, the taxonomic multi-attribut decision-making method has been developed to assess the items (risks), where the experts' opinions have been obtained in the form of the interval numbers.A comprehensive and hierarchical structure to indentify logestics risks has been devised and a set of indicators to assesse risks suggested.this is based on the literature and the method of supply chain risk breakdown structure(SCRBS) and focus on the study of a advanced good-manufacture industries.

A comprehensive questionare to assesse the identified risks has been obtained and opinions of experts as definite number have been collected having a statistical approach then the opiniones were collected and summarized on the format of interval number.Applying the taxonomy analysis method with an approach to interval number,then the logestice risk was assess and prioritized.

2. Therertical fundamentals

2.1. Taxonomic analysis method

The multi-attribut decision-making methods are used to prioritize a limited countable number of the predetermined items based on a set of decision-making attribut, while the basis includes modeling, constructing and establishing a contingency (Azar&Rajabzadeh,(2002)).Hereby,the taxonomic analysis method can be mentioned as one of the most important multi-attribut decision-making methods (Azar&Rajabzadeh,(2002); Asgarpour, (2008)).Since the determination of the relative weights of the attribut based on the experts' opinions is not needed, as a result, the qualitative judgments of the experts and the practitioners in the analysis is less interventional unlike any other decision-making methods, therefore, it could be stated that the results are less uncertain (Tzeng& Huang, (2011)). This method was introduced for the first time in 1763 by Adenson and it was developed in 1950 by a group of mathematicians. The taxonomic analysis of the different categorizations is used in various sciences, in which the particular type is numerical taxonomy. Numerical taxonomy is used to assess, grade and ranking the similarities of the taxonomic units. In this method, a more or less homogeneous series are divided and the plausible attribut is constructed to examine and measure the level of development at disposal of the planners. This method is based on the analysis of a series of the indicators to prioritize the available items and a full categorization scale is represented to assess the items (Azar& Rajabzadeh, (2002)).

2.2 Interval numbers theory

For the first time, the interval system theory was introduced in 1982 by Deng in Huazhong University of Science & Technology in China (Kay, 1994). Since the fuzzy logic is used to study the complex and uncertain problems and systems, the interval system theory is used to study the semi-complex and sem-definite problems (Liu & Lin, 2006). This theory has two essential advantages in comparison with the other methods of the system analysis, whereas it is capable of the analysis of the systems, while the data analysis and semi-fuzzy data systems are required.

2.2.1. **Interval numbers**

Interval numbers are akin to atoms and cells of the interval system (Key, 1994),If the number, $\otimes x$, is defined as following,

$$\otimes x = [\underline{x}, \overline{x}] = \{x | \underline{x} \le x \le \overline{x}, \underline{x} \text{ and } \overline{x} \in R\} \quad (1)$$

This series may be defined as following:

1) If $\underline{x} \to \infty$ and $\overline{x} \to \infty$, the number $\otimes x$ is called a fuzzy number. This number is dedicated to a decision-making criterion, in which there is no significant information,

2) If $\underline{x} = \overline{x}$, the number, $\otimes x$, is defined as a definite number,

The use of the definite number in decision-making means the total confidence of the decision-maker on a criterion or item,

3) If $\underline{x}, \overline{x} \in R$, $\underline{x}, \overline{x} \neq \infty$, $\otimes x$ is called a interval number. This equation means that in such hypothesis, there is inadequate or ambiguous information.

Although it seems that the interval numbers are akin to the fuzzy numbers, the major difference between the interval numbers and the fuzzy numbers is that the accurate value of the interval numbers is unknown, however, the range of the value of the number is a given or in other words the accurate value of the left and right boundaries is definite and clear. While the number is defined as a range in a fuzzy number, however, the accurate number of the left and right boundaries is unknown and a membership function is followed. This subtle difference between the interval number and the fuzzy number implies that the calculations of the interval numbers are very simple in comparison with the fuzzy numbers, since the membership function for the left and right boundaries of a fuzzy number along with the complexity and computational operations. Therefore, the concepts and the operations of the interval numbers are used to deal with the indefinite information usefully.

Definition (2). Mathematical operators of interval numbers

The basic mathematical operations of 2 interval numbers $\otimes x = [\underline{x}, \overline{x}]$ and $\otimes y = [\underline{y}, \overline{y}]$ are defined as following (Lino et al. 2008):
The equation of the addition of 2 interval numbers:

$$\otimes x + \otimes y = [\underline{x} + \underline{y}, \overline{x} + \overline{y}] \quad (2)$$

The subtraction is defined as:

$$\otimes x - \otimes y = [\underline{x} - \overline{y}, \overline{x} - \underline{y}] \quad (3)$$

The multiplication is defined as:

$$\otimes x \times \otimes y = [\min(\underline{x}\underline{y}, \underline{x}\overline{y}, \overline{x}\underline{y}, \overline{x}\overline{y}), \max(\underline{x}\underline{y}, \underline{x}\overline{y}, \overline{x}\underline{y}, \overline{x}\overline{y})] \quad (4)$$

The division defined as:

$$\otimes x \div \otimes y = \left[\min\left(\frac{\underline{x}}{\underline{y}}, \frac{\underline{x}}{\overline{y}}, \frac{\overline{x}}{\underline{y}}, \frac{\overline{x}}{\overline{y}}\right), \max\left(\frac{\underline{x}}{\underline{y}}, \frac{\underline{x}}{\overline{y}}, \frac{\overline{x}}{\underline{y}}, \frac{\overline{x}}{\overline{y}}\right)\right] \quad (5)$$

In addition, the equations (6) and (7) include the multiplication of a fixed number by a interval number and the reverse of the interval number is shown as:

$$k \times \otimes x = [k\underline{x}, k\,\overline{x}] \quad (6)$$

$$\otimes x^{-1} = \left[\frac{1}{\overline{x}}, \frac{1}{\underline{x}}\right] \quad (7)$$

Definition (3): Minkowski distance
Minkowski distance is defined between two interval numbers $\otimes x$ و $\otimes y$ ($\mathbf{MD}(\otimes x, \otimes y)$) as following (Dang et al,2006).

$$\mathbf{MD}(\otimes x, \otimes y) = \sqrt{\frac{1}{2}\left[(\underline{x} - \underline{y})^2 + (\overline{x} - \overline{y})^2\right]} \quad (8)$$

3. Interval taxonomy analysis method

The multi-attribut decision-making methods are used to prioritize, m item(s) based on the basis of n indicator(s) based on the quantitative assessment of each item for each indicator used in the decision-making matrix. In these problems, the information related to the items, the attribut, and their preferences depending on the judgments of the decision-makers. According to the decision-makers' knowledge about the items and the indicators, thus the assessments can be recorded for definite, fuzzy or interval numbers in the decision-making matrix. In order to solve such problems in terms of total confidence, uncertainty and the lack of confidence, the decision-making definite, interval and fuzzy mathematical methods have been developed (Dong et al, 2008).
If the decision-maker uses any insufficient data of the decision-making items and indicators, they can indicate their opinions in the form of interval numbers in the decision-making matrix. Futhermore, the interval numbers are capable to mix the definite decision-making matrices of a set of decision-makers in a problem provided in the decision-making matrix. The quantities , in the definite decision-making matrices

turn to a interval number in the interval decision-making matrices. Thereafter, the taxonomy methos is developed with the interval decision-making matrix, so that items can be prioritized in those problems that the inadequate information and the uncertain relationships will be provided in the system. The phases of the developed method are as following:

Phase (1): Identification of items and indicators

In the first phase, the decision items and indicators of the problems are identified. In the risk management problem of the logistics, the risk identification is done by the assessment items and attribut, e.g. probability and intensity of impact in this phase. In the present study, a hierarchical and comprehensive structure of the logistics risk (SCRBS Structure) has been developed to identify the risks.

Phase (2): Construction of decision-making matrix

decision matrix $\otimes \boldsymbol{G}$ is constructed based on the opinions of the decision-maker.

$$\otimes \boldsymbol{G}=\begin{bmatrix} \otimes G_{11} & \otimes G_{12} & & \otimes G_{1,k} & \otimes G_{1,k+1} & & \otimes G_{1,n} \\ \otimes G_{21} & \otimes G_{22} & & \otimes G^{*}_{2,k} & \otimes G^{*}_{2,k+1} & \cdots & \otimes G_{2,n} \\ \vdots & & & \ddots & & & \vdots \\ \otimes G_{m1} & \otimes G_{m2} & \cdots & \otimes G_{m,k} & \otimes G_{m,k+1} & \cdots & \otimes G_{m,n} \end{bmatrix}$$

Where n is the number of decision indicators, m is the number of items and interval numbers $\otimes G_{ij}$ are the decision matrix elements includingthe comments with respect to the decision-maker on the item, i, and the index, j. In the present study, a questionnaire is designed to evaluate the experts' opinions on the logistics risks in respect to the evaluation attribut in the format of the definite numbers in the range of 1-9. After the questionnaires are collected in respect to the data table of the notions on each risk (item) in proportion with the inserted attribut upon the distribution of the experts' opinions of the assessment of a specific risk in relation to a specific indicator, the opinions with lower and higher frequency than the first and third quartiles due to the discrepent data and opinions are removed and the first and third quartile of the observations are tracked as the interval number in the decision-making matrix. Thus, the experts' opinions are collected and summarized in the decision matrix of $\otimes \boldsymbol{G}$.

Phase 3: Normalization of decision-making matrix

In respect to the scale and the different units of the indicators in the decision-making matrix, the items cannot be compared. The normalization by removing the units and descaling the elements of the matrix, the items can be compared in terms of all indicators. The Equations (9) and (10) are applied to normalize the positive indicators (when the indicators more, they are more appropriate) and negative (when the indicators are less, they are more appropriate) and the construction of the normal decision-making matrix $\otimes \boldsymbol{G}^{*} = [\otimes G^{*}_{ij}]$, respectively (Tzeng & Huang, 2011).

$$\otimes G^{*}_{ij} = \left[\frac{\underline{G}_{ij}}{G^{max}_{j}}, \frac{\bar{G}_{ij}}{G^{max}_{j}}\right], G^{max}_{j} = max_{1\le i\le m}\{\bar{G}_{ij}\}, \text{ j=1,2,…..,n} \quad (9)$$

$$\otimes G^{*}_{ij} = \left[\frac{G^{min}_{j}}{\bar{G}_{ij}}, \frac{G^{min}_{j}}{\underline{G}_{ij}}\right], G^{min}_{j} = min_{1\le i\le m}\{\underline{G}_{ij}\}, \text{ j=1,2,…..,n} \quad (10)$$

One of the features of the normalization functions in Equations (9) and (10) is that, after the normalization of the positive and negative indicators, all of the positive indicators change direction. It means that the decision-making matrix is positive for all indicators in $\otimes \boldsymbol{G}^*$ matrix.

Phase (4): Construction of reference or ideal item

According to the taxonomy method, the items should be prioritized by the elements of the matrix $\otimes \boldsymbol{G}^*$ via the sequence of the reference, in which it is indeed called the given ideal item, where all of the indicators consist of the best values(Golmohammadi&Mellat parast,2012). The given ideal item A* is an item which is consisted of the maximum interval elements of the columns of $\otimes \boldsymbol{G}^*$according to Equation (11).

$$A^* = \left\{ \begin{matrix} [\max_{1\le i\le m} \underline{G}^*_{i1}, \max_{1\le i\le m} \overline{G}^*_{i1}], \dots, [\max_{1\le i\le m} \underline{G}^*_{ik}, \max_{1\le i\le m} \overline{G}^*_{ik}], \\ \dots\dots [\max_{1\le i\le m} \underline{G}^*_{in}, \max_{1\le i\le m} \overline{G}^*_{in}] \end{matrix} \right\} \quad (11)$$

Phase 5. Homogenization of items

In this phase, the development of the heterogeneous items in the taxonomy method occurs in the interval data status. In this section, for each indicator, j, as Minkowski distance accords Equation (8) between the both items based on the interval data matrix calculated in the matrix, $\otimes \boldsymbol{G}^*$. Suppose that Minkowski distance (a definitge number) between the items, i and k for the indicator, j, represented by MD^j_{ik}. MD_{ik} is equal to the sum of Minkowski distances between the both items, i and k, based on all indicators calculated as following.

$$MD_{ik} = \sum_{j=1}^{n} MD^j_{ik} \quad (12)$$

After the calculation of each item, the other items in proportion to the indicators is determined and finally the mean and standard deviation of these distances are obtained, whereas $\overline{MD}_i$ and σ_i are the mean and the standard deviation of Minkowski distance of the item, i, in relation to the other items. In order to identify the heterogeneous items, the plausible limit, the upper limit (UC) and the lower limit (LC) are calculated according to Equations (13) and (14).

$$LC = \overline{\overline{MD}} - 2\bar{\sigma} \quad (13)$$

$$UC = \overline{\overline{MD}} + 2\bar{\sigma} \quad (14)$$

As $\overline{\overline{MD}}$ and $\bar{\sigma}$ are the mean values of $\overline{MD}_i$ and σ_i , respectively. According to the taxonomy method, the items with the Minkowski distance determined at the limit of the other items, $\overline{MD}_i$, are included, except the synchronous items and the items with excluded limit of $\overline{MD}_i$ due to the asynchronicity sholuld be removed in the series of the items. After the adjustment of the items, again the decision-making matrix is constructed without removed items and the above phases are repeated, thus all of the items are not removed according to the above equation.

Phase VI. Determination of distance of items from ideal item

In this phase, each item, i, from the given ideal item, A^*, Cio_i is calculated according to Equation (15). Close a small gap represents the preferred option is the ideal option. The close distance means the vicinity of the target item from the ideal item.

$$\mathrm{Cio_i} = \sqrt{\sum_{j=1}^{n} [\mathrm{MD}(\otimes G_{ij}^*, \otimes A_j^*)]^2} \qquad (15)$$

In the above equation, $\mathrm{MD}(\otimes G_{ij}^*, \otimes A_j^*)$ represents Minkowski distance between the two interval numbers $\otimes G_{ij}^*$ and A_j^*.

Phase VII: Determination of development ratio of items

In this phase, the degree of development and the status of the options is discussed. The development ratiuo of an item, F_i (status of an item), is calculated in the following equation by taxonomy method.

$$F_i = \frac{Cio_i}{Co} \qquad (16)$$

In this equation, Cio_i is the distance of each item from the ideal option and Co is the upper limit development constraint. In order to calculate Co, the average $(\overline{Cio})$ and the standard deviation (σ_{Cio}) of the values of $\mathrm{Cio_i}$ is calculated in Phase (6). The equation of the upper limit development is obtained as following,

$$Co = \overline{Cio} + 2\sigma_{Cio} \qquad (17)$$

Phase VIII: Ranking and determination of significance of items

In the last phase of taxonomy method, the items are arranged in the sequence of F_i in terms of development. Each option's development values are between zero and one.
Higher values closed to zero for an option show more development (at the position of higher rank) and the values closed to 1 exhibit underdevelopment.

4. Identification and assessment of logistics risk

At the present, technology growth in manufacturing industry of complex products in developing countries is thriving. Study and research, design and product development, growth of applied basic and developmental science, manufacture, purchase, sales and the support of the most important missions in these industries. Logistics involves the preparation and construction phase of a product from raw material supply to distribution and delivery of finished product to the customer and its support is the most important missions of these industries.
Supply and production activities are two of the most important activities of logistics process in advanced products industry. Identifying and assessing the risks of these two

sectors

help to develop appropriate programs to deal with the risks and give rise to success of the industry.

In this study, together with literature review and studying one of the advanced products industry, risks of both the supply and production of the logistics process are identified and they are ranked based on opinions given by a number of industry experts and using taxonomic method. The risk management process steps are described in case study which is provided in the next sections.

Phase I: Identification of risks and risk assessment attribut

In this phase, we first identify risks of logistic in both the supply and production sections based on literature.

Opinions of Experts were collected by utilization of group decision-making techniques e.g. Delphi and brainstorming methods in different levels of employees in the given industry based on different positions among three statistical population of the experts, middle managers and the deputies, who amounted to 30 people in total. Finally, a series of comprehensive and hierarchical structure of failure in supply chain risk (SCRBS) is provided.

At this phase, 44 chief risks and 16 assessment attribut are identified as attribut of risk taxonomy method. Table 1 shows the list of the potential risks identified.

Table 1. Risks and factors constructing the supply and manufacture areas in the logistics process of the advanced products

Risk source	Risk topic	Symbol	Indicators (factors)						
			1	2	3	4	5	6	7
Supply	Limitation of number of suppliers with the proper conditions	RS1	√			√			√
	problems of technical documentation of supply of subsidiaries and materials	RS2	√			√			
	Delays in on-time commitments and supply of raw materials by contractor	RS3						√	√
	Lack of proper continuous and reliable interaction with subcontractors towards building the subsidiaries	RS4				√			
	Poor quality of raw materials used by contractor	RS5						√	√
	Increase of costs and deliverable raw materials by contractor	RS6						√	√

Risk source	Risk topic	Symbol	Indicators (factors)						
			1	2	3	4	5	6	7
	Incapability to meet demands by contractor	RS7						√	√
Supply	Inflexibility of rapid technological impactability and customer demands (employer-employee)	RS8							√
	Financial problems of contractor about employer's guarantees	RS9							√
	Insufficient funds in contractor's inventory due to improper material planning	RS10							√
	Bankruptcy of supplier and probable disconnection with industries	RS11						√	√
	Environmental risks (strike, war and terrorism)	RS12						√	
	budget policy alterations	RS13						√	
	Governmental regulatory and tax policies alterations	RS14						√	
	Surveillance and protection issues	RS15				√			
	International sanctions and raw material supply problems by contractor	RS16	√					√	
	Disclosure of foreign purchase process	RS17				√			
	Fault in identification of purchase of dometic parts in the market	RS18					√		
	Fault in identification of purchase of parts in the international market	RS19	√				√		
	Human fault in-house contractors of organization	RS20							√
	Inappropriate shipment circumstances	RS21					√		
producte	Machine malfunction (discontinued manufacture)	RP1					√		
	Less quality of raw materials in production process	RP2							√
	Staff demand changes and consequent product design change	RP3			√				
	Fault in production planning and inventory control	RP4					√		
	Fault in assembly line quality control	RP5					√		
	Inappropriate leading of production/coordination of test programs	RP6					√		

Risk source	Risk topic	Symbol	Indicators (factors)						
			1	2	3	4	5	6	7
	Product equipments transportation failure in assembly line	RP7					√		
	Operator/equipment fault of production line and increasing returns in assembly line	RP8					√		
	Lack of flexibility to improve or change industrial sub-delivery	RP9							√
	Improper transportation of assembly line materials	RP10					√		
	Staff deficiency (missionary)	RP11					√		
	Improper storage and warehouse environment impacts	RP12					√		
	Inappropriate use of product by customer	RP13		√					
	Environmental problems	RP14					√		
	Dependence on only one supplier	RP15	√			√			√
	Environmental risks (laws, governmental policies, taxations, economic developments and sanction)	RP16						√	
	Promotion of scientific experts/operators for serving customers (inappropriate use of product and increased returns for repair)	RP17		√					
	Research tests analysis faults (operator/equipment/software)	RP18					√		
	Disclosure or loss of information or documentation process	RP19				√	√		
	Change of macro plans and organizational policies	RP20						√	
	Inappropriate or incorrect duty assignment for staff	RP21					√		
	Less staff safety and health	RP22					√		
	Change in organizational structures and mission of sectors	RP23					√	√	

The risk factors are represented in the following table.

Table 2. Risk factors of logistics in the production and supply areas

Factor no.	Description of risk factor
1	High level of production technology
2	Poor interaction with customer

3	Regional and global challenges and threats
4	Cooperation conditions and protection and security issues
5	Activity failure and management problems within industry
6	Environmental impacts and economic sanctions and limited raw material supply
7	Contractor's technological capacbility and capacity constraints (financial, production and human resources)

Risk is defined as the uncertain event or condition that, if it takes place, it can have positive or negative effect on its target. Therefore, the event probability and the efficacy include the both major risk assessment attribut, however, some researchers Additional have added some other attribut depending on the risk assessment circumstances. For example, in some literature, some measures have been mentioned, e.g. the organization's capability to respond to risk (Mikulak et al, 1996) and insecurity of estimations (Kirk, 1998). Both of the above measures can be used for the qualitative or quantitative attribut in the risk assessment and the categorization very well. In this regard, (Lambert et al. 2001) have categorized the risk sources in three indicators: event probability, potential impact on project and risk management agility ratio. In oder to assessment the logistics process risks, there are two attribut represented in Table 2. Since, in the taxonomic method, the weighted attribut are not compared, some highly important measure could be ignored with the low probability in the logistics process. In the present study, for any risk, the risk probability and the risk efficacy raete on the main industrial objectives through the logistics, including schedules, costs, performance quality and range of activities of various secotrs and the different areas of the chain have been defined as the primary indicator of risk (PIR) for each risk (Equation 18).

$$PIR = \sum_{i=۱}^{۴}\left[W_i\left(P \times I_i\right)\right] \qquad (18)$$

In this equation, W_i is the significance of efficacy in the logistics, whereas the data are obtained via the survey.

Only the use of the conventional indicators and the impact rate would not present any comprehensive, reliable and credible result, therefore, in the present study, 11 additional indicators are selected. In this phase, the experts' opinions on the rate of 11 secondary indicators (complementary) for each risk has been considered and the taxonomic analysis method is used on the final assessment of categorization of the risks, thus the decision-making matrix is constructed.

The assessment attribut with the positive efficacy (negative) means that whenever the value of these attribut is higher for a specific risk, the degree of criticality of that risk is more (less).

Table 3. Risk assessment attribut of supply and production sectors in logistics process

Criterion	Criterion	Symbol	Impact aspect	Ideal item

type				$\underline{x}$	$\overline{x}$
Primary	Probability of risk	P	positive	**1.0**	**0.9**
	Impact of risk on schedules	I_1	positive	**1.0**	**0.8**
	Risk-cost impact ratio	I_2	positive	**1.0**	**0.8**
	Risk impact ratio on performance quality	I_3	positive	**1.0**	**0.8**
	Risk impact ratio on range of activities	I_4	positive	**1.0**	**0.8**
Secondary	Risk impacts on industrial mission justification	SIR_1	positive	**1.0**	**0.8**
	Risk impact on reducing customer satisfaction	SIR_2	positive	**1.0**	**0.7**
	Risk exposure	SIR_3	positive	**1.0**	**0.8**
	Risk manageability	SIR_4	negative	**1.0**	**0.3**
	Feasible risk identification	SIR_5	negative	**1.0**	**0.3**
	Estimation reliability	SIR_6	negative	**1.0**	**0.3**
	Risk reduction	SIR_7	negative	**1.0**	**0.3**
	Risk security impacts	SIR_8	positive	**1.0**	**0.7**
	Environmental impacts of risk	SIR_9	positive	**1.0**	**0.7**
	Mental and psychological impacts on employees	SIR_{10}	positive	**1.0**	**0.7**
	Risk impact on reduction on low employee satisfaction	SIR_{11}	positive	**1.0**	**0.7**

Phase II. Construction of decision-making matrix

In order to asses the risks, a questionnaire is made for the survey among 30 subjects, as the industrial experts, upon the risk assessment attribut (Table 3), except the event probability, on each risk (Table 1) in Likert scale of 1-9. Whereby the experts were required to asses the event probability of each risk at the scale of 0-1. Therefore, 30 decision-making matrice have been constructed for each expert with the size of 16 attribut and 44 risks. The necessary of the risk analysis with the interval taxonomy method is the construction of the decision-making matrix based on the experts' notion. According to the dispersion of the experts' opinions, the experts' score is not limited to a number upon any risk and any indicator, in order to merge the opinions for each element of the decision-making matrix, the quartile functions were used in the statistics. The opinions were less or more removed in the first and third quartiles of the observations in each element as the deviated opinions and the first and third quartiles of the observations consisted of the upper and lower limits of the interval number. Thereby,

the
matrix(whit 44*16 dimension) is obtained with the interval numbers that represented in the appendix .

Phase III. Construction of standard matrix and ideal item
By using the Equations (9)-(10), the elements of the decision-making matrix are normalized. According to the normalized decision-making matrix and by using Equation (11), the ideal item is constructed and it has the value amoing all indicators. The number of the ideal item is shown in Table 3 for each indicator.

Phase IV: Determination of Euclidean distance between items
As it is mentioned, it is primarily necessary to measure Minkowski distance between risk i and k per each criterion i according to the normal decision-making matrix, MD_{ik}^{j} according to Equation (8). Then, the values of MD_{ik} are calculated based on the both risks in Equation (12). The mean and standard deviation of the values of MD_{ik} ($\overline{MD_i}$, σ_i) are calculated for each risk. Finally, the means of $\overline{MD_i}$ and σ_i are calculated as it is shown in Table 5, thus with them and the Equations (13)-(14) at the allowed, reception limit of the heterogenous risks are determined.

Table 4. Mean and allowed limit of Euclidean distance of items

Euclidean distance Average of items ($\overline{\overline{MD}}$)	Double standard deviation of items Euclidean distance ($\overline{2\sigma}$)	Upper limit (LC) ofEuclidean distance of items	Lower limit (LC) of Euclidean distance of items
1.069	**1.207**	**2.276**	**-0.138**

The risks with the value of $\overline{MD_i}$ out of the defined limit are excluded in the assessment process due to heterogeneity.In this study when the value of $\overline{MD_i}$ is examined for each risk, i, it is shown that none of the identified risks is inconsistent and all of them remain in the assessment process.

Phase VI: Other indicators of taxonomy method and categorization of risks
As mentioned in phases 6-7 on the taxonomy method, for each risk, the distance from the ideal item Cio_i should be calculated according to Equation (15). The results are represented in Table 5. Subsequently, a variable is calculated based on the distance from the ideal item ratio the distance *i*th item from the ideal item towards the maximum distance of the items from the ideal item as the level of development according to Equation (16). The level of development per risk (F_i) is represented in Table 5. By determining the development ratio of each item, the significance level and the numerical value *F*i any of the risks listed in ascending order of the smaller to larger values is categorized 1-44 for all items (risks).

Table 5. Results of prioritization of production and supply risks of logistics process with taxonomic method

Risk rank	F_i	Cio_i	$\overline{MD_i}$	σ_i	Risks

1	0.456108536	0.2504	1.854	0.807	R13
2	0.526310239	0.2889	1.543	0.424	R37
3	0.526485351	0.4634	1.563	0.694	R5
4	0.535714583	0.2940	1.389	0.690	R16
5	0.53893098	0.2958	1.638	0.715	R12
6	0.573952936	0.3931	1.232	0.579	R1
7	0.62045647	0.3406	1.093	0.429	R17
8	0.625526857	0.3433	1.084	0.464	R14
9	0.665991524	0.4634	0.985	0.493	R7
10	0.670013511	0.4634	1.017	0.452	R9
11	0.692482292	0.4634	1.244	0.543	R6
12	0.705039401	0.3870	1.017	0.355	R20
13	0.712957801	0.3913	1.348	0.468	R15
14	0.71626621	0.3931	1.062	0.348	R19
15	0.726977654	0.4000	0.879	0.419	R3
16	0.72869586	0.4000	0.881	0.387	R39
17	0.738275211	0.4052	0.850	0.431	R22
18	0.746218093	0.4096	0.738	0.396	R28
19	0.748721326	0.4110	1.140	0.381	R21
20	0.756061942	0.4150	0.850	0.437	R23
21	0.764703661	0.4197	0.790	0.410	R11
22	0.765819967	0.4203	0.907	0.418	R10
23	0.767996968	0.4215	0.820	0.346	R36
24	0.776576256	0.4263	0.762	0.315	R18
25	0.782157413	0.4424	0.849	0.406	R2
26	0.789433577	0.4333	0.890	0.447	R42
27	0.806087562	0.4424	0.806	0.453	R29
28	0.807864336	0.4434	1.431	0.642	R40
29	0.813570091	0.4466	0.780	0.416	R24
30	0.822831633	0.4516	0.778	0.405	R41

31	0.844206796	0.4634	0.896	0.457	R44
32	0.845368064	0.4640	0.908	0.528	R26
33	0.8466844	0.4647	0.968	0.527	R34
34	0.847733047	0.4634	0.826	0.485	R8
35	0.853643623	0.4634	1.007	0.520	R4
36	0.86699309	0.4759	1.088	0.573	R31
37	0.87664759	0.4812	0.901	0.548	R25
38	0.87919804	0.4826	0.965	0.515	R27
39	0.88727279	0.4870	1.088	0.638	R38
40	0.909177756	0.4990	1.032	0.658	R30
41	0.916848047	0.5032	1.036	0.629	R32
42	0.916966088	0.5033	1.044	0.659	R33
43	0.926210638	0.5084	1.362	0.667	R43
44	0.935636367	0.5136	1.608	0.843	R35

In order to determine the priority of the both fields of supply and manufacture, the average rating of the items 1–21 determine the degree of significance and the rate of risks in the field of supply and the items 22–44 determine the degree of significance of the process(production) area. The above calculations are optained according to contents in the R column in table 5 and Equation (19).

$$\mathbf{0 \leq F_i \leq 1}$$

(19) $$\text{average rating of supply field} = \frac{\sum_{i=1}^{21} R_i}{21}$$

$$\text{average rating of production field} = \frac{\sum_{i=22}^{23} R_i}{23}$$

In order to determine risk rank, R_i is used with supply and production risk rank in Equation (19).

According to Equation (19), the ranking of the supply area is 14 and the ranking of the production area is 30 and it can be seen that the risks associated with the supply and the supplier have the lowest risk among the total 44 risks, including the three important risks of the present study as the most critical risks: 1. fiscal, monetary and budget policy alterations of organization, 2. environmental risk (regulations, governmental policies, taxation, economic developments and sanctions), 3. poor quality of raw materials used by contractor. In the present study, the strategic plan and innovations are proposed to respond the significant risks: 1. Increased customer satisfaction, 2. Establishing cooperation offices at customer's site, 3. improved production quality and capacity, 4. research and development to construct customer requirements, 5. increased research and innovation funding level.

6. Conclusion

In regard of the significance of logestics in the manufacture and service provider organizations, it encompasses the entire activities related with the missions of the organzation, thereby the administration of this sector would be highly critical. In this study, the literature and the case study of the potential risks of logistics have been identified and the risk break down structure is used based on the notion of the exeperts and classified into two categories of supply and production. The risk assessment and categorization is applied to identify the important risks of a multi-attribut decision-making, in which the risks are assessed by the experts based on many attribut, e.g. the probability and the severity of the consequences. The experts' opinions about any risk and criterion can be modeled into the absolute, fuzzy or interval numbers. Due to the relative uncertainty of the experts' opinions, the taxonomy multi-attribut decision-making approach is applied in this research and the interval data are developed. 44 risks and 16 attribut have been identified for the prioritization of the risks in the both supply and manufacture sectors in the logistics management and prioritized according to the interval taxonomic approach. The risk assessment results show that the effective risks in the field of raw materialsupply are more important than the risks in the field of manufacture and production. Furthermore, 10 significant risksin total 44 items in the research include: 1. fiscal, monetary and budget policy alterations of organization, 2. environmental risk (regulations, governmental policies, taxation, economic developments and sanctions), 3. poor quality of raw materials used by contractor, 4. international sanctions and raw material supply problems against contractor, 5. environmental risks (strike, war and terrorism), 6. limitation of number of suppliers with the right conditions, 7. problems of purchase process, 8. fluctuations in governmental regulations and tax policies, 9. inability of contractor to meet demands (due to missing forecast of seasonal and short-term life cycle of product), 10. financial problems of contractor and required guarantees of contractor. It is necessary that the managers of the industries subject to the advanced products, particularly the corporate executives under study, reciprocate these10 risks and provide the requisite supervisions.

References

a) Vanany, I., Zailani, S., Pujawan, N., (2009). Supply Chain Risk Management: Literature Review and Future Research. 16 Int'l Journal of Information Systems and Supply Chain Management, January-March, 2(1), 16-33.

b) Tang, C. S., (2006). Perspectives in supply chain risk management. International Journal of Production Economics, 103 (2), 451-488.

c) PMI (Project Management Institute)., (2004). a Guide to the Project Management Body of Knowledge (PMBOK Guide), Pennsylvania, Newtown Square.
d) Hillson, D., (2003). Using a risk breakdown structure in project management. Journal of Facilities management, 2 (1), 85–97.
e) Tang, O., Musa, S. N., (2011). Identifying risk issues and research advancements in supply chain risk management. Int. J. Production Economics, 133(1), 25–34.
f) Olson, D. L., Wu, D. D., (2010). A review of enterprise risk management in supply chain. Kybernetes, 39 (5), 694-706.
g) Thun, J. H., Hoenig, D., (2011). An empirical analysis of supply chain risk management in the German automotive industry. Production Economics, 131 (1), 242-249.
h) Craighead, C. W., Blackhurst, J., Rungtusanatham, M. J., Handfield, R. B., (2007). The Severity of Supply Chain Disruptions: Design Characteristics and Mitigation Capabilities. Decision Sciences, 38 (1), 131–156.
i) Norrman, A., Jansson, U., (2004). Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident. International Journal of Physical Distribution & Logistics Management, 34 (5), 434-456.
j) Ritchie, B., Brindley, C., (2000). Disintermediation, disintegration and risk in the SME global supply chain. Management Decision, 38 (8), 575-583.
k) Jia, F., Rutherford, C., (2010). Mitigation of supply chain relational risk caused by cultural differences between China and the West. International Journal of Logistics Management, 21 (2), 251-270.
l) Tuncel, G., Alpan, G., (2010). Risk assessment and management for supply chain networks: A case study. Computers in Industry, 61 (3), 250-259.
m) Matook, S., Lasch, R., Tamaschke, R., (2009). Supplier development with benchmarking as part of a comprehensive supplier risk management framework. International Journal of Operations & Production Management, 29 (3), 241-267.
n) Chapman, C. B., Ward, S. C., (2003). Project Risk Management: Processes, Techniques and Insights. John Wiley, Second edition. UK: Chichester.
o) Pipattanapiwong, J., (2004). Development of multi-party risk and uncertainty management process for an infrastructure project, Doctoral dissertation, Japan, Kochi University of Technology.
p) McDermott, R. E., Mikulak, R. J., Beauregard, M. R., (1996). The basics of FMEA, New York: Quality Resources.
q) Klein, J. H., Cork, R. B., (1998). An approach to technical risk assessment. International Journal of Project Management, 16 (6), 345-351.
r) Waterland, L. R., Venkatesh, S., Unnasch, S., (2003). Safety and Performance Assessment of Ethanol/Diesel Blends (E-Diesel), Cupertino, California.
s) Baccarini, D., Archer, R., (2001). The risk ranking of projects: a methodology. International Journal of Project Management, 19 (3), 139-145.
t) Pertmaster Software., (2002). Pertmaster Project Risk v7.5: Tutorial, manual and help, Available on: http://www.pertmaster.com.
u) Xu, L., Liu, G., (2009). The study of a method of regional environmental risk assessment. Journal of environmental assessment, 90 (11), 3290-3296.
v) Oke, A., Gopalakrishnan, M., (2009). Managing disruptions in supply chains: A case study of a retail supply chain. Int. J. Production Economics, 118 (1), 168-174.

w) Braunscheidel, M. J., Suresh. N. C., (2009). The organizational antecedents of a firm's supply chain agility for risk mitigation and response. Journal of Operations Management, 27 (2), 119-140.
x) Ritchie, B., Brindley, C., (2007). Supply chain risk management and performance A guiding framework for future development. International Journal of Operations & Production Management, 27 (3), 303-322.
y) Kleindorfer, P. R., Saad. G. H., (2005). Managing Disruption Risks in Supply Chains. Production and Operations Management, 14 (1), 53-58.
z) Chopra, S., Sodhi, M. S., (2004). Managing risk to avoid supply-chain breakdown. MIT Sloan Management Review, 46 (1), 53-61.
aa) Liu, Z., Lai, M., Zhou, T., Zhou, Y., (2009). A Supply Chain Risk Assessment Model Based on Multistage Influence Diagram. 6th International Conference on Service Systems and Service Management, 8-10 June, Pp. 72-75. IEEE, E-ISBN: 978-1-4244-3662-0.
bb) Juttner, U., (2005). Supply chain risk management: Understanding the business requirements from a practitioner perspective. The International Journal of Logistics Management, 16 (1), 120-141.
cc) Ziegenbein, A., Nienhaus, J., (2004). Coping with Supply Chain Risks on Strategic, Tactical and Operational Level. Proceedings of the Global Project and Manufacturing Management Symposium. Siegen. pp. 165-180.
dd) Manuj, I., Mentzer, J. T., (2008). Global supply chain risk management strategies. International Journal of Physical Distribution & Logistics Management, 38 (3), 192-223.
ee) Roshan S. G., Nukala, V., (2004). A Conceptual and Analytical Framework for the Management of Risk in Supply Chains. In Proceedings of the 2004 IEEE International Conference on Robotics and Automation, 26 April - 1May, New Orleans, vol 3, pp. 2699-2704.
ff) Wagner, S. M., Bode, C., (2006). An empirical investigation into supply chain vulnerability. Journal of Purchasing & Supply Management, 12 (6), 301-312.
gg) Giannakis, M., Louis, M., (2011). A multi-agent based framework for supply chain risk management. Journal of Purchasing & Supply Management, 17 (1), 23–31.
hh) Wagner, S. M., Neshat, N., (2010). Assessing the vulnerability of supply chains using graph theory. Int. J. Production Economics, 126 (1), 121-129.
ii) Sabio, N., Gadalla, M., Guille´n-Gosa´lbez, G., Jime´nez, L., (2010). Strategic planning with risk control of hydrogen supply chains for vehicle use under uncertainty in operating costs: A case study of Spain. International journal of hydrogen energy, 35 (13), 6836-6852.
jj) Ravindran, A. R., Bilsel, R. U., Wadhwa, V., Yang, T., (2010). Risk adjusted multi attribut supplier selection models with applications. International Journal of Production Research, 48 (2), 405-424.
kk) Ellis, S. C., Henry, Raymond, M., Shockley, J., (2010). Buyer perceptions of supply disruption risk: A behavioral view and empirical assessment. Journal of Operations Management, 28 (1), 34-46.
ll) You, F., Wassick., J. M., Grossmann, I. E., (2009). Risk Management for a Global Supply Chain Planning under Uncertainty: Models and Algorithm. American Institute of Chemical Engineers, 55 (4), 931–946.

mm) Azaron, A., Brown, K. N., Tarim, S. A., Modarres, M., (2008). A multi-objective stochastic programming approach for supply chain design considering risk. Production Economics, 116(1), 129-138.

nn) Goh, M., Lim, J. Y. S., Meng, F., (2007). A stochastic model for risk management in global supply chain networks. European Journal of Operational Research, 182 (1), 164-173.

oo) Faisal, M. N., Banwet, D. K., Shankar, R., (2006). Supply chain risk mitigation: modeling the enablers. Business Process Management Journal, 12 (4), 535-552.

pp) Zsidisin, G. A., Ellram, L. M., (2003). An Agency Theory Investigation of Supply Risk Management. The Journal of Supply Chain Management, 39 (3), 15-27.

qq) Azar, A., Rajabzadeh, A., (2002). Applied decision making (Eds.). Negahe Danesh Publisher: Tehran.

rr) Tzeng, G. H., Huang, J. J., (2011). Multiple Attribute Decision Making: Methods and Applications. (Eds.). Chapman and Hall/CRC.

ss) Asgarpour, M. J., (2008). Multiple attribut decision making (8rd ed.). University of Tehran press, 2008.

tt) Bayazidi, B., Oladi, B., Abbasi, N., (2012). The questionnaire data analysis using by SPSS software (PASW) 18, Mehregan, Tehran, in persion.

uu) Mahdavi, I., Mahdavi-Amiri, N., Heidarzade, A., Nourifar, R., (2008). Designing a model of fuzzy TOPSIS in multiple attribut decision making. Applied Mathematics and Computation, 206 (2), 607–617.

vv) Sifeng liu, &Yi lin(2006). Grey Information: Theory and practical applications. Springer.

ww) David K (1994). Grey System and grey Relational Model ACM SIGCEBulletin. The Journal of GreySystems 20, 1-9.

xx) Wiecek M., &Ehrgott M., &Fadel G., & J. R. Figueira (2005). Multipleattribut decision making for engineering Omega, 36, 337-339.

yy) Yong-Huang Lin, &Pin-Chan Lee, &Hsin-I Ting (2008). Dynamic Multi-Attribute Decision Making Model with Grey Number Evaluations. Expert Systems with Applications, 35, 1638–1644.

zz) Golmohammadi D., Mellat-parast M., (2012) Developing a greybased decision-making model for supplier selection, Int. J. Production Economics 137, 191–200