Ranking of Risks in Supply Chain by Lean Production Approach

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Abstract: The objective of this study is assessment of the role of lean production elements in supply chain and evaluation & ranking of various risk factors, According to the definition of risk (Uncertainty reflects a situation in which there are shortage of information, knowledge and comprehension of each probable output) models using AHP and Expert Choice software which deals with the classification criteria of the selected article.
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1. Introduction

The objective of this study is assessment of the role of lean production elements in supply chain and evaluation & ranking of various risk factors in order to increase their flexibility in the supply chain. The competitive world of today where productivity has increased in every field, only those organizations are successful that are successfully able to make the best of their conditions and minimize the risks of their industry. The same applies to SCM, i.e. a chain with minimum risk and maximum flexibility would be selected. Purchasing and supply management are widely acknowledged as strategic for companies, because they contribute to build and to maintain a competitive advantage (Ellram and Carr, 1994; Mol, 2003; Hsu et al., 2006). The increasing complexity of products and services, characteristically shorter product lifecycles, globalization of trade, and the improvements in logistics have led companies to focus on their core businesses (Van Weele and Rozemeijer, 1996). Product competition is now frequently between competing supply chains rather than at the organizational level (Christopher, 1992). The issue of risk in supply chain is becoming more and more important for the following reasons (Christopher and Lee, 2004):

. Uncertainty in supply and demand (see also Tang, 2006);
. Globalization of the market;
. Shorter and shorter product and technology life cycles; and
. Increased use of outsourcing.

Even though supply risks can be reduced through improved processes and buffer strategies organizations still need to take actions against unforeseen events because risk cannot be completely eliminated. A supply chain is a complex network, which consists of all stages (e.g. order processing, purchasing, inventory control, manufacturing, and distribution) involved in producing and delivering a final product or service. The entire chain connects customers, manufacturers and suppliers, beginning with the creation of raw material or component parts by suppliers, and ending with consumption of the product by customers. Like the term "supply chain", outsourcing has become part of the business lexicon since the 1980s. Outsourcing in an indiscriminate fashion, however, could hurt company image and customer trust.

As indicated in our literature review, there have been many models of supplier selection. Each model has its advantages and limitations. For instance, the analytic hierarchy process (AHP) method (Saaty, 1990) is a widely used model for solving multiple criteria problems. The AHP forces the user to evaluate the importance of each criterion in relation to others. However, consistency of the individual's judgments is not always achieved. Also, the AHP is incapable of handling correlation between criteria. When the criteria are not independent, the AHP could produce biased results (Levary, 2007). More generally, the AHP makes the alternative analysis concealed by simply averaging the users' judgment without revealing diversified perspectives.

2- Overview on Philosophical Aspect of Subject

2.1. Risk

Uncertainty reflects a situation in which there are shortage of information, knowledge and comprehension of each probable output. Shortage of information and knowledge means probabilities and result of each output. At a very general level, risk is defined as the probability of a variation in the expected result. E.g. in a scenario that a person expect a certain outcome of his/her efforts and the result is less than what was originally excepted, risk deals with the results of such output . In fact supply chain risk management refers to management risk in supply chain and attempts to adapt itself with environmental conditions by flexibility (Sylwia Konecka, 2010).

2.1. Supply Chain

Supply chain is a chain which includes any activities related to product and material process, from supplying raw material to delivery of final product to the consumer. Organizations are constantly trying to improve their share of market, increase profits and achieving the competitive advantages over competitors. To achieve these goals, effectiveness and efficiency of supply chain is of utmost importance in any organization (Hosseini, Rahmani and Habibi, 2009). In fact, activities in the supply chain are oriented towards reducing the costs and thereby enhancing their competitive advantage (Sylwia Konecka, 2010). To integrate the supply chain, exchange of information between members of the supply chain must be swift and accurate. Coordination in information and planning activities leads to cost reduction, value improvement and implementation of coherent planning activities (Hosseini, Rahmani and Habibi, 2009).

Growing trend in utilization of internet and web-based electronic markets provides a favorable opportunity for businesses to effectively manage supply chain. Using this infrastructure, organizations can produce according to the requirements and excess unnecessary inventory costs (Hosseini, Rahmani and Habibi, 2009). Solving the problems of supply chain organizations requires high levels of cooperation, joint decision making, improved and increased information sharing. In this situation, managers must ensure that their transacting business party operates towards the interest of the whole chain (Hosseini, Rahmani and Habibi, 2009). Supply chain management attempts to reduce the risk in the supply chain and thereby follows objectives such as improvement of customer satisfaction, optimization, inventory management and more profitability. In this regard, suppliers and their management play an important role (Kazem, Zahedi, 2009). In 60s and 70s, to increase competitive capabilities, organizations tried to produce a product with better quality and at a reduced cost by improving their internal processes & standardization. At the time the dominate mentality was that strong engineering & designing and also cohesive and coordinate production process are the pre-requirement to access market demands and therefore achieving more market share. Therefore organizations made their best efforts to increase to increase efficiency.

Increase in variety of patterns excepted by the customers in 80s resulted in increasing flexibility of organizations in production lines development of new products to meet such demands. In 90s, in addition to improving production process and utilizing renewed engineering models, many managers of industries found out for their continued existence in the market improving internal processes and flexibility in company's capabilities is not enough but parts and material suppliers should also produce material with the best quality and least costs and distributors of such products must maintain a close relationship with the producer's market development policies. With such approach, supply chain approaches and its management were developed. On the other hand with rapid development of information technology in recent years and its vat application in supply chain management, many of the fundamental activities of chain management with new methods (Hosseini, Rahmani and Habibi, 2009).

2.3. Lean Production

Many of the concepts used in lean production are not new and most of them were used in 1920s in Ford Automobile Manufacturing Company and most of industrial engineers are familiar with them (Alem Tabrizi & A. Bgherzadeh, 2009). In 1997 the first article about production system of Toyota is published. In these conditions computer system are used for logical organization of production and introduction of current unnecessary costs. Its focus is Kanban method because it's simple and powerful. Lean production includes several different aspects which encompass cases such as Just in Time (JIT) production, teamwork, cell production and etc. in an integrated system which can establish synergy in works resulting in production of commodities demanded by customers with the least possible waste in time (Abdulmalek and Rajgopal, 2007). Lean production is among the major initiatives American companies use to increase their competitive advantage in global market and its focus is on reducing costs by eliminating activities which produce no added value (Hosseini, Rahmani and Habibi, 2009).

Manden in his book defines Toyota production system as a sensible method for production which eliminates unnecessary elements resulting in cost reduction. He believes that the main objective of the system is cost reduction but in achieving that the following sub-objectives are also achieved:

- JIT system, i.e. production of demanded items by number and within time required.
- Automation (Jidoka in Japanese), i.e. preventing faulty items to proceed into next process
- Flexible workforce (Shojinka in Japanese), i.e. changing the number of workers according to demand variation
- Creative thinking (Soikufu in Japanese), i.e. investment on worker's suggestions (Alam Tabriz & A. Bgherzadeh,2009)
- Lean production has fundamental difference with the traditional mass production. Therefore considering it is wrong to assume that the same performance assessment criteria in mass production can successfully assess the performance in lean production. For this

purpose scholars and authors have introduced criteria with consideration of lean production elements.

Voomak et al in their studies describe criteria to assess the performance of lean production in the factory level in automobile manufacturing industry which is constituted of productivity (each car assembly hours) and quality (faults in the assembly of each car).

The major advantages of lean production method are as follows:

1) Increasing the productivity of work force
2) Reducing throughput time (up to 90%): Throughput time is defined as time required for the delivery of a product to the purchaser from the raw material to the final product.
3) Increasing quality
4) Reducing time to market of the product
5) Reducing warehouse inventory (up to 90%)

The concept of "lean" in the life cycle of the product, from before the establishment of its producing factory up to after its commencement and development is also considered. In this relation the establishment conditions of a new factory can be considered as following scenarios:

- An investor invests for establishment of a new factory.
- An existing factory establishes a new factory in order to develop its activities
- The workshop of an artisan develops its facilities and activities and gradually becomes a factory.

The "birth" of an industrial unit is formed based on the design of a specific product and based on that product other parts of the factory are designed and implemented. Therefore the lifecycle of a product with consideration of its producing factory can be defined as follows:

A) Investment
B) Designing and establishment of factory
C) Designing of organization and work flow systems of the factory
D) Operating the factory

The concept of being "lean" in each of the aforesaid stages is implemented in the system by any means and lean production cannot be limited to only the operating stage of the factory. The main challenge in JIT production is successful coordination of production activities. For example an automobile is constituted of thousand parts. The majority of factories utilize a push system in which parts are manufactured and transferred into next operation or the warehouse. Fault in the process or demand fluctuation consequently introduces imbalance in the inventories between various operating sectors. Pull production in which items are produced or delivered only when required start from the last operational sector and moves backward throughout all production process work stations and continues without interruption to even subcontractors and suppliers. The objective of this system is to establish a smooth and swift process for all products from the time of receiving purchased material and parts up to the time of the final product being delivered to the customer. In a pull system the customer is the reason for production movement and consuming material. Pull production starts by external customer and all of the return ways to the production process is initiated by the downstream or internal customer of each operation. This is a market oriented approach for production.

2.4. Pull as opposed by Push

Pull production eliminates wastes that results from the more traditional push systems, i.e. materials moved from upstream to the lower stream operation as long as it's available. In push system, accessibility to raw material justified production and supply of material is based on predicting customer demand. It is a production oriented philosophy and leads to excess production or delay in delivery. To avoid delay, inventory is created in the warehouse and the link of critical process. Bottlenecks occur when downstream processes cannot accompany upstream production and push for production is resulted from excess upstream production rather than real market demand.

2.5. Advantages of Pull Production

At company's level, adopting pull production bears the following advantages:

1) Strong cost reduction
2) Efficient utilization of work force
3) Facilitating in identifying problems which require solving

Pull production methods results in more job satisfaction for the personnel because:

1) They would perform the work related to customer's demand;
2) They would acquire higher skill levels;
3) They would become enhanced to improve work flow (option) (Alam Tabriz & A. Bgherzadeh, 2009)

2.6. Lean Supply Chain

New concepts such as lean, agility and etc. used as tools for competitive advantage in supply chain were studied. Their objective in supply chain is to eliminate unnecessary factors, aka Mudas. This can be performed by factors such as eliminating redundancy and valueless factors. Lean supply chain emerged because of fundamental factors in completion such as quality, price and etc. and their interactions. The basic criterion in lean chain is reaction capability and flexibility (Sylwia Konecka, 2010).

3. Research Objectives

In this research we aim to find lean production indexes effective on supply chain and our

case study is performed in a dairy company by using questionnaires distributed between the personnel of this unit (managers, department heads and employees) and its customers to found out the effective factors. In addition the basis of the work is the indexes presented in the article "Lean and agile supply chain management concepts in the aspect of risk management". Objectives of this study are classified as follows:

3-1) Investigating lean production indexes effective in supply chain

3-2) presenting scientific and applied solutions in increasing the flexibility of supply chain

3-3) Classifying and prioritizing risk indexes in the aforesaid industry

4. Research Questions

In the current study questions are about the effect of available indexes on SCM and their ranking by DM.

In this study we tried to indicate risk criteria in addition to specifying the priority of each risk.

1- Which are the indexes affecting risk?

2- How is the prioritization of these indexes?

5. Scope of Research

The scope of this study encompasses production and operation management which can be carried out in various fields such as service level increase models, customer satisfaction and etc.

The spatial scope of this study is the dairy company and time scope is 2011-12.

6. Research Method

In method, this study is descriptive – applied study which uses multi-criteria decision making mathematical methods and hierarchical analysis technique of AHP to examine the relation between risk factors and SCM and prioritizes by using computations and pair comparison. Because the characteristics of the study's populations are evaluated through surveying, researchers have analyzed the variable without changing the characteristics of the society. This method is suggested based on human analysis of complex and fuzzy problems. This method was suggested by a researcher named "Thomas L Saaty" in 1970s and since then various applications of this model has been discussed for this method.

7. Data Collection Tools

Part one: includes general information about the necessity of performing this study among managers for which several reasons has been set forth in this study.

Table 1. Part two: includes the main questionnaire and the range of answers to the questions is prepared as follows:

Relative number	definition
1	Same significance
3	Relatively important
5	important
7	Very important
9	Significantly important

Our data are from a statistical population of managers of "Tin" dairy company and some of these individuals had more working experience. In order to answer the research questions three general methods were used for data collection:

1) Studying articles, books, internet and various references and etc

2) Interview with professors, experts and managers of industry and academic centers about effective indexes on SCM risk

3) Preparing questionnaire for investigating the relative importance between indexes and ranking them for five expert and company's managers

The following table is the result of combining 4 tables which are filled out by 4 DM. The computation of each cell is as follows:

	value	financial	economic criteria	reliance	commitment	relationships	confidence in decision making	potential partners
value		.319	.537	.359	319.	.191	.903	1.682
financial	3.130		1.682	1.414	1.225	.427	1.682	3.984
economic criteria	1.861	.595		.841	1.075	.42	1.414	3.162
reliance	2.783	.707	1.189		.756	.33	1.732	4.472
commitment	3.13	.816	.93	1.316		.473	2.3	4.82
relationships	5.244	2.34	2.378	3.027	2.115		2.913	5.657
confidence in decision making	1.107	.595	.707	.577	.435	.343		1.934
potential partners	.639	.251	.316	.206	.207	.177	.517	3.984

It is possible that in a decision making, instead of one DM we have several DMs and all of their opinions must be considered in each board.

In these cases of team decision making we can use geometrical mean for the matrix elements of $D = \| a_{ij} = w_i/w_j \|$, therefore:

Number of decision makers: l = 1,2,…,k; $a\acute{o}_{ij} = \{\prod_{l=1}^{k} a_{ijl}\}^{1/k}$

i ,j = 1,2,…,n ; i ≠ j

if any DM, by consideration of his/her specialty and responsibility, should have more impact on the votes, a weight (w_i) can be designated to his/her opinions and consequently the following equation is used:

$$a\acute{o}_{ij} = \left\{\prod_{l=1}^{k} a_{ijl}{}^{w_l}\right\}^{\frac{1}{\sum w_l}}$$

For example, for cell no. 1-3 (value – economic criterion), the experts' opinions is respectively equal to ½, 2, ½ , and 1/6. In this case the sum of this cell equals to:

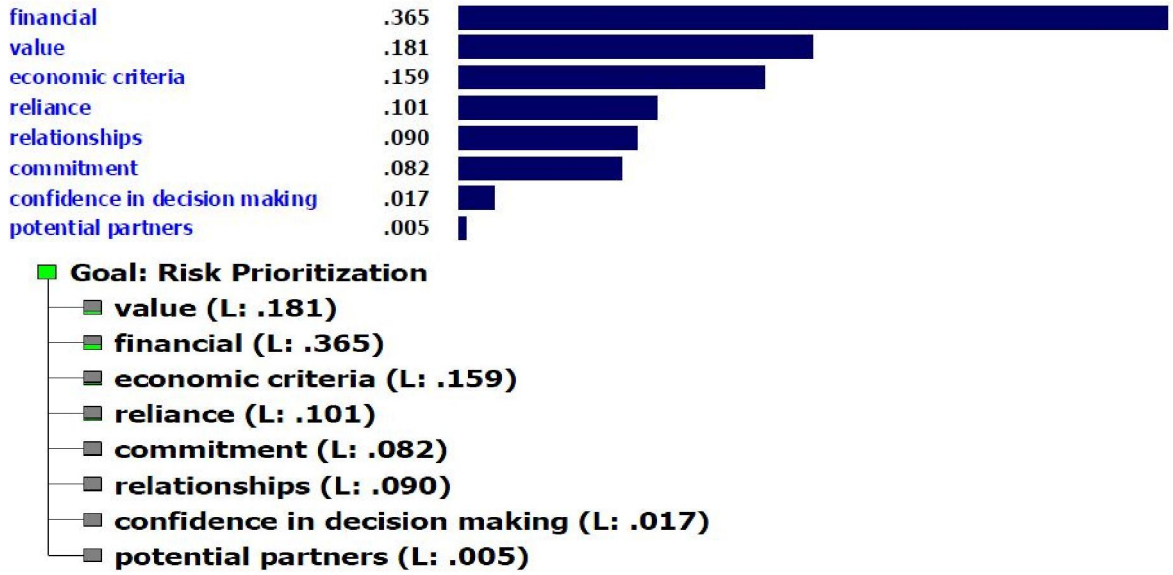
$$\prod_{1}^{4} a_{ij}^{\frac{1}{k}} = \left[\frac{1}{2}.2.\frac{1}{2}.\frac{1}{6}\right]^{\frac{1}{4}}$$

$$= \left[\frac{1}{12}\right]^{\frac{1}{4}}$$

$$= 0.537$$

8. Data Analysis

In order to analyze the collected data from the process, hierarchical analysis is used because this technique allows the formulation of the problem as a hierarchy and also provides the option to consider various qualitative and quantitative criteria. This process incorporates various choices in the decision making and is based on pair comparison which facilitates judgment. By using part 2 of the questionnaire which provides the ranking of factors based on the indexes, multi-criteria decision making model by Expert Choice software was solved. Considering that consistency rate is less than 0.1 the agreed upon pair comparative group matrix of the indexes has an acceptable consistency.



In the following table the significance of indexes is set forth. Based on AHP the indexes are prioritized on declining basis in table 3.

Table 3. Significance of indexes

No.	Prioritizing indexes effective on risk based on AHP	Significance
1	financial	.365
2	value	.181
3	economic criteria	.159
4	reliance	.101
5	relationships	.090
6	commitment	.082
7	confidence in decision making	.017
8	potential partners	.005

9. Conclusion

Considering prioritizing indexes in the previous section, indexes of financial, value respectively were the most significant and indexes of potential partners, confidence in decision making respectively were the least significant in risk. Combination of financial, value index constitutes 54% of the total effect on risk. Considering the characteristics of MCDM main risk factors can be divided into subsidiary factors and achieve valuable results in the further studies. The current studies and its results can be of services to industrial experts so that by having a full comprehension of the conditions and prioritizing they can help advancing and making more flexible the SCM in the aforesaid industry. A

comprehensive information system can reduce risk effects in the industry and contribute to reducing The Bull Whip Effect.

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