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A Hybrid Model for Evaluating Leagile Supply Chain Performance in Industry

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Abstract

Supply chain management (SCM) is one of the most important of the areas that have recently generated a great deal of interest in both industry and academia. SCM is considered an integrating philosophy to manage the total flows of materials, products and information from suppliers to the ultimate customers. The changing conditions of competition, for organizations to become more responsive and also more efficient are driving the interest in the concept of supply chain agility and leanness. The main objective of this paper is to suggest an index to reflect the agility and leanness of companies and corresponding SCs in the industry. The purpose of this paper, providing an index using two paradigms, Lean supply chain and Agile supply chain, to evaluate the Company's performance. Therefore, company to review its supply chain list, a series of criteria that are discussed in paradigm, and weighted those uses AHP method. The company evaluated its performance using a standardized questionnaire designed.

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Introduction

To the believe of many experts, in today's competitive world, the competition level has been stretched from companies to their supply chains and having an efficient and agile supply chain, is a crucial competitive advantage in the competition (Ketchen and Hult, 2007; Kuei and Madu, 2001). Naylor, Naim and Berry (1999), define the supply chain a system of material suppliers, production facilities, distribution services and customers, which are connected to each other through a forward flow of materials, information flow and feedback. Azevedo, Carvalho, Duarte and Cruz-Machado (2012), consider the supply chain management integration between the company and its suppliers, through the development of supplier partnerships and strategic alliances. Quinn (1997) defines the supply chain as a set of practices related to the movement of goods from raw materials to the end users. Some of these practices include sourcing and procurement, production planning, order processing, inventory management, transportation, warehousing and customer services. Dawe (1994) argues that for efficient supply chain management, thorough effort in all duties and responsibilities in a company should be accomplished. Supply chain management is an important factor to achieve and maintain competitive advantage (Mohammed, Shankar and Banwet, 2008). Li and Ragu-Nathan (2005), believe that supply chain management is a basic prerequisite for the growing profitability in the global competition of rivalry. Martin and Patterson (2009), claim that due to the need of companies to productivity and supply chain efficiency, in general, companies will have to review, evaluate and use of supply chain management concepts. Changing conditions of rivalry and increase of environmental turbulence and required by organizations, has made unavoidable the concept of being lean agile for the supply chain to increase efficiency and accountability of organizations (Mistry, 2005). The concept of agile suggest the sensitivity of the market and the ability to understand and respond effectively to actual demand (Collin and Lorenzin, 2006) and the concept of being lean seeks to eliminate additional activities and non-value-added to achieve higher levels of performance, profitability and resilience (Anand and Kodali, 2008). Simultaneous integrity of the concepts of lean and agile supply chain, leads to greater performance, efficiency and sustainability in the supply chain (Chan and Kumar, 2009).

Many studies have been conducted in the field of supply chain in the world, which in this research has been focused only on one aspect of the supply chain. Supply chain of auto companies are a good example to illustrate the use of two paradigms of being lean and agile simultaneously in supply chain. In the automobile manufacturing supply chain, exploit from the paradigm of lean benefit to reduce interest expense, while reducing the cost of investment over time due to more efficient use of equipment and facilities, they use agile manufacturing system. The main objective of this research is to provide an index for the simultaneous combination of agility and being lean in supply chain of industries and organizations. This index investigates a set of evaluation criteria of agility and being lean of supply chain. Then, after a investigating literature of lean and agile supply chain and providing Leagile supply chain index, this model has been studied in three manufacturing organization. So the main question of this study is what criteria on a lean and agile supply chain is effective? And on the other hand, the importance of these criteria is how much? Finally, we are looking to have simultaneous attention on being lean and agile in the supply chain and investigate and compare an organization status based on three criteria of agility, purity and Leagile.

Theoretical Foundations and Background of Research

DeGroote and Marx (2013) in a study, have investigated the role of IT in supply chain agility and performance. They have considered the measure of the ability to understand and respond to market changes as supply chain agility. To do this, the researchers have collected data from supply chain managers in 193 US companies and analyzed them. The results showed that information technology improves supply chain ability to understand the market changes, improved efficiency, accuracy, availability and timeliness of information flow within the supply chain. Also enhancement of the supply chain agility, have had positive effects on sales, market share,

profitability and customer satisfaction of studied companies. Agarwal, Shankar and Tiwari (2007) in an article modeled the supply chain agility. They identified 4 important dimensions in agile supply chain and studied them in the organization. These four dimensions include processes, planning, marketing and information.

Lean approach primarily focuses to reduce waste. This thinking eventually led to a real increase in value, increasing customer satisfaction and profitability (Womack, Jones and Roos, 1991). Disney, Naim and Towil (1997) state that lean thinking by eliminating waste in the supply chain creates value. Waste in the supply chain can be measured in the standards of time, inventory, unnecessary costs and activities that don't add value. Qi, Boyer and Zhao (2009), consider the main objective of the study of lean supply chain, strategy formulation and strategy, in order to reduce costs and increase productivity through eliminating waste in the internal and external processes of companies. Table 1, states the standards of lean supply chain from the perspective of several researchers.

At the operational level, lean paradigm runs by some techniques such as Kanban, organizing the workplace, intuitive control and Poka-Yoke (Melton, 2005). The implementation of lean supply chain paradigm, leads to improvements in costs, flexibility, circulation of stock and prevention of defects and ultimately productivity (Chan and Kumar, 2009).

Agile word in the dictionary means to move fast, agile, active, quick and easy mobility and being able to think for bold and with a clever method employed, but in the current environment, agility means of effective reaction to variable and unpredictable environment and using these changes as opportunities for organizational improvements (Agarwal, Shankar and Tiwari, 2007). This concept first was introduced by Iacocca in a meeting of many scientific experts and industry executives to find the causes of the failure of companies to deal with environmental challenges and changes, in a report entitled "Manufacturing firm strategy in the 21 century: a vision of industry professionals". Christopher (2000) defines agility as follows: 'agility is defined as an organization's ability to respond quickly to changes in demand, in both volume and variety." According to Tolon (2000), agility represents effective supply chain integration and emphasizes long-term and close relationships with customers and suppliers.

To gain competitive advantage in the changing business environment, companies in the event of effectively operation must collaborate and cooperate in addition to their institution with suppliers and customers for the appropriate level of agility (Christopher and Towill , 2002). In this case, the agile supply chain is formed. An agile supply chain is able to appropriatly react to changes that occur in the workplace (Agarwal, Shankar and Tiwari, 2007). Agility in the supply chain-could be defined as follow "The ability of a supply chain to react quickly to changes in market and customer needs". In studies of researches and papers in the field of agile supply chain, the criteria that scholars have insisted on them, have been collected in Table 2. Agile supply chain states organizations needs to develop and coordinate its relationships with business partners, including suppliers, manufacturers and distributors. The table 3 summarizes some recent research on Agile and Lean subjects.

Table 1: Lean Supply Chain Indicators

Researchers	Lean Supply Chain Indicators
Treville and Antonakis (2006)	Respect for People
Anand and Kodali (2008)	Customer Relationship
Demeter and Matyusz (2011)	Total quality management - timely production - Maintenance
Gurumurthy and Kodali (2009)	Timely production - relations with suppliers / long-term relationships in business
Stewart and Grout (2001)	Correction of mistakes

Table 2: Agile Supply Chain Indicators

Researchers	Agile Supply Chain Indicators
Lin, Chiu and Chu (2006)	Cooperation of chain partners - Process integration - Integration of information - the sensitivity of the market - customer sensitivity
Agarwal, Shankar and Tiwari, 2007	The sensitivity of the market - customer satisfaction - quality - speed of delivery - data accuracy - New Product Introduction - centralized and cooperative planning - integration of process - using information technology - reducing production-time - improving service levels - Minimize costs - minimize uncertainty - to minimize resistance to change - trust development
Swafford, Ghosh and Murthy (2008)	Using information technology - the ability to understand and respond to changes - quickly improve customer service - reduce product cycle time - rapidly increasing new product introduction
Kisperska-Moron and Swierczek (2009)	The sensitivity of the market - virtual organization - process and network integration
Khan, Bakkappa and Sahary (2009)	The proper response to market volatility - rapidly respond to the unique needs of customers
Yusuf, Gunasekaran, Musa, Dauda, El-Berishy and Cang (2014)	Enriching customer - leverage effect of people and information - Cooperation for competition - understanding change and uncertainty

Table 3: Summary of Research

Researchers	Summary
Banerjee and Ganjeizadeh (2017)	Researchers details the modelling approach for calculating leagility index. The calculation is proposed using conjoint analysis. The sustenance model further optimizes the supply chain using Simulated Annealing (SA) using a practical process adoption scheme.
Rajesh (2018)	Researchers in this research, the sequence of evolution of resilient and sustainable supply chains has been investigated with respect to the positioning of partition line in supply networks.
Masood, Hoda and Blincoe (2018)	This study describes the constraints the students faced while applying agile practices in a university course taught at the University of Auckland.
Liu and etal. (2018)	This study investigates the link between cloud computing and organizational agility based on survey data from users of the Alibaba cloud in China.
Xu and Koivumaki (2018)	The objective of this research is to investigate alternative approaches under a time-constrained setting. A high-tech case within the challenge piloted the agile effectuation of a business model with three parallel approaches: effectuation, causation and lean startup method, thus providing antecedent on how effectuation theory can be integrated with agile development and business model theory.
Ravichandran (2018)	This study examines two key antecedents of organizational agility, namely the IT competence of a firm and its innovation capacity and, examine their independent and joint effects on agility.
Marodin and etal. (2018)	This paper draws on configurational theory to investigate the moderating role of lean product development (LPD) on the effects of Lean Manufacturing (LM) on quality and inventory performance.
Message Costa and	The aim is to consolidate the existing knowledge about the application of

etal. (2018)	L&SSi in the food industry, analyze the Lean, Six Sigma and Lean Six Sigma initiatives (L&SSi) evolution within the sector and identify the relevant aspects of implementation such as drivers of adoption, critical success factors, tools and methods applied, barriers faced and benefits obtained.
Al-Aomar and Hussain (2018)	This paper addresses this gap using a structured study plan with specific research questions. To this end, a theoretical framework of lean assessment for value creation is first developed and a SIPOC-based construct of a hotel supply chain is used to identify and categorize hotel waste
Babalola, Ibem and Ezema (2019)	This paper relied on a systematic review of published literature in Scopus, Science Direct and Google Scholar to identify and categorize the different lean practices implemented in the construction industry and the benefits derivable from them.

Leagile Index in Supply Chain

To investigate the behavior of companies and organizations in the supply chains in terms of characteristics and attributes (lean and agile supply chain approach), a series of criteria and indicators arise. Table 4 reports the model notation (variables and parameters).

Figure 1 represents the relationships between these criteria.

Table 4: Model notation

i	Number of Agile and Lean criteria
j	Number of Organizations
P_{A1} , P_{A2} , … , P_{An}	Agile criteria
P_{L1} , P_{L2} , … , P_{Ln}	Lean criteria
W_{Ai}	weight of Agile criteria
W_{Li}	weight of Lean criteria
B_A	behavior of Agile criteria
B_L	behavior of Lean criteria

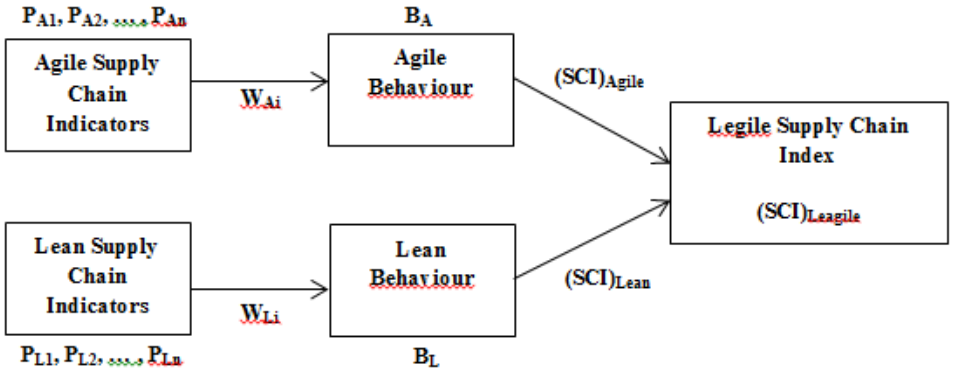

Figure 1: The relationship between the Indicators and behavior of Organization

As can be seen in the figure, lean or agile index in a company depends on two factors: the first factor, evaluation criteria of lean or agile supply chain are (PAi & PLi) that these criteria are definable generally and they were mentioned in the preceding sections. The weight of these criteria can be determined with the decision and ranking techniques (e.g. the

Hierarchy Analytic method), so that these weights are numbers between zero and one, and their sum will be equal to one.

Eq. 1 $$0 < W_{Li}, W_{Ai} < 1$$

Eq. 2 $$\sum_{i=1}^{m} W_{Li} = \sum_{i=1}^{n} W_{Ai} = 1$$

The second factor s the corporation behavior on determined criteria (BA & BL), which is possible to calculate using the questionnaire. To determine the behavior of a company, the Likert 5 Choice Spectrum is utilized.

Thus, the lean and agile index in a company is a function of the weight of standards and behavior of company in these criteria. For example, for j company the lean and agile indexes are calculated as the following equations.

Eq. 3 $$(SCI_j)_{Lean} = f(W_{Li}, B_{Li})_j = \sum_{i=1}^{m} [W_{Li} * (B_{Li})_j]$$

Eq. 4 $$(SCI_j)_{Agile} = f(W_{Ai}, B_{Ai})_j = \sum_{i=1}^{n} [W_{Ai} * (B_{Ai})_j]$$

In relations 3 and 4, WA_i and WL_i values are representing the weight of the criteria for agile supply chain and lean supply chain. Values $(BA_i)_j$ and $(BL_i)_j$ respectively indicate j vompany behavior in agile and lean supply chain standards.

Based on the stated criteria for lean supply chain and agile supply chain, overall index of Leagile supply chain for J Company can be expressed as a function of two indices.

Eq. 5 $$(SCI_j)_{Leagile} = f((SCI)_{Lean}, (SCI)_{Agile})_j$$

Each enterprise, selects its supply chain strategy depending on the type of product (standard products and new or innovative product or hybrid product). Companies that produce standard products, since the changes in the variety of their products is less than other products, benefit from lean supply chain properties. The companies that their products are innovative, due to rapid changes in demand and the market, in the early stages of the product life cycle, use agile supply chain properties and after reaching the stage of development, use the lean supply chain. Finally, companies that their products are combined, consider the properties of Leagile supply chain the best strategy (Banihashemi, 2011).

So in relation 5, it is possible to determine weight of lean (WL_{SC}) and agile (WA_{SC}) supply chain strategies. These weights such as the weights of supply chain metrics (W_{Li} & W_{Ai}) are calculated based on decision-making techniques.

Eq. 6 $$0 < W_{LSC}, W_{ASC} < 1, W_{LSC} + W_{ASC} = 1$$

Eq. 7 $$(SCI_j)_{Leagile} = (W_{LSC} * (SCI_j)_{Lean}) + (W_{ASC} * (SCI_j)_{Agile})$$

In an overall conclusion, and with respect to the expressed relationships, in a summary index of lean/ agile supply chain in j company can be stated as follows.

Eq. 8 $$(SCI_j)_{Leagile} = W_{LSC} * (\sum_{i=1}^{m} W_{Li} * (B_{Li})_j) + W_{ASC} * (\sum_{i=1}^{n} W_{Ai} * (B_{Ai})_j)$$

So the index of Leagile supply chain will be a number between 1 to 5. Number 1 means the absence of evidence of establishing lean and agile supply chain, and number 5 also means there is strong evidence to establish lean and agile supply chain.

Case Study

In the review and implementation of presented model of research, two questionnaires have been used. The first questionnaire includes 11 questions that were distributed among the three studied organizations. The first question of the questionnaire, has investigated the attitude of managers of organizations about the presented definitions and explanations, on lean and agile supply chain, in general. The next questions investigate the attitudes of people about the importance of criteria established in terms of the effectiveness of the supply chain. The second questionnaire of study, which includes 10 questions, studied the behavior of the assessed company, individually. In order to verify the reliability of questionnaire, Cronbach's alpha coefficient was calculated which is expressed in Table 5.

In analyzing the data, according to the first question questionnaire number (1) of survey, the importance of lean and agile supply chains and weights are calculated.

As can be seen in Table 6, and according to the respondents, the importance of agile supply chain in organizations is more than lean supply chain. In the following the weight and importance of supply chain agility and leanness criteria and its impact on organizational performance were evaluated. Tables 7 and 8 show the decision matrix of agile and Lean criteria by AHP. The results are presented in Table 9 below.

CR Index for Decision Macking Matrix of Agile supply chain is 0.051 and CR Index for Decision Macking Matrix of Lean supply chain is 0.096.

In the following the behavior of studied organizations are investigated in each of the criteria of lean and agile supply chain.

Table 5: Cronbach's alpha of questionnaire

	Organization 1	Organization 2	Organization 3	Total
N	11	11	10	32
Cronbach's alpha Coefficients	0.763	0.909	0.723	0.865

Table 6: Analysis of the studied organizations

Variables	Average	Rank	Weight
Agile	4.28	1	0.55
Lean	3.50	2	0.45
N	32		
Pearson correlation coefficient	0.738		
The significance level	0.000		

Table 7: Decision Macking Matrix of Lean supply chain criteria by AHP

	L1	L2	L3	L4	L5
L1	1	0.612	0.311	0.811	0.371
L2	1.634	1	0.209	2.179	0.509
L3	3.215	4.785	1	3.951	0.499
L4	1.233	0.459	0.253	1	0.205
L5	2.695	1.965	2.004	4.878	1

Table 8: Decision Macking Matrix of Agile supply chain criteria by AHP

	A1	A2	A3	A4	A5	A6
A1	1	0.415	0.588	0.211	2.110	0.385
A2	2.410	1	1.028	0.305	1.815	0.417
A3	1.701	0.973	1	0.411	1.540	0.509
A4	4.739	3.279	2.433	1	2.718	1.240
A5	0.474	0.551	0.649	0.368	1	0.505
A6	2.597	2.398	1.965	0.806	1.980	1

Table 9: Statistics of weight of supply chain criteria

Row	Factors	Number	Weight importance
Supply chain agility metrics			
1	Use of information technology and its distribution	32	0.092
2	The ability to change decisions based on market sensitivity	32	0.133
3	The focus and quality improvement in order to respond quickly to customer needs	32	0.128
4	The ability to rapid change in design and manufacture products	32	0.323
5	Flexibility in production and response to market volatility	32	0.086
6	The ability to change the delivery of products to customers	32	0.237
Supply chain Lean metrics			
1	Cost-cutting strategies	32	0.092
2	Minimum inventory and save on the purchase of raw materials	32	0.141
3	The ability to on-time production	32	0.327
4	Proper and timely maintenance of Machines	32	0.080
5	The error correction and standardization work	32	0.359

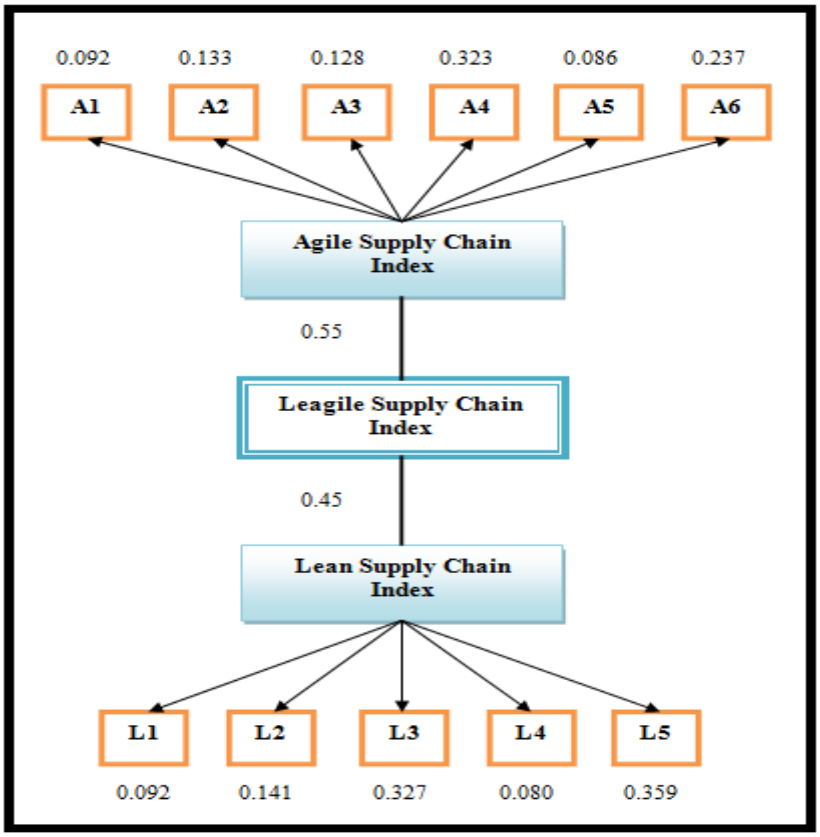

Figure 2. The importance coefficient of the Leagile supply chain criteria

Table 10: Analysis of the studied organizations

Row	Factors	Weight	Average of organization 1	Average of organization 2	Average of organization 3
Supply chain agility metrics					
1	Use of information technology and its distribution	0.092	3.64	3.36	3.30
2	The ability to change decisions based on market sensitivity	0.133	4.27	3.91	3.70
3	The focus and quality improvement in order to respond quickly to customer needs	0.128	3.91	3.55	4.30
4	The ability to rapid change in design and manufacture products	0.323	4.18	3.64	3.90
5	Flexibility in production and response to market volatility	0.086	4.27	3.55	4
6	The ability to change the delivery of products to customers	0.237	3.91	4	3.60
N		32	11	11	10
lean standards of supply chain					
1	Cost-cutting strategies	0.092	3.18	3.27	3.40
2	Minimum inventory and save on the purchase of raw materials	0.141	4	3.64	3.50
3	The ability to on-time production	0.327	3.73	4	4.40
4	Proper and timely maintenance of Machines	0.080	3.55	3.55	3.50
5	The error correction and standardization work	0.359	3.82	3.55	4.40
N		32	11	11	10

As shown in Table 10, according to the relations 3, 4 and 5 score of indexes of lean, agile and Leagile supply chain for any organization is calculated which is presented in Table 11 below.

Table 11: The general analysis

The final index	Operation	Weight	Average	The Final Score			Supply chain strategy
				Organization 3	Organization 2	Organization 1	
3.847	2.117	0.55	3.85	3.80	3.71	4.04	SCI_{Agile}
	1.728	0.45	3.84	4.11	3.68	3.74	SCI_{Lean}
				3.940	3.696	3.905	$SCI_{Leagile}$

Supply chain agility index in the first organization is more than lean and lean/agile index. So agile supply chain in this organization is more applicable. In the second organization the situation is the same, but in the third one a lean supply chain has more effectiveness on the performance of the organization.

In the overall analysis of three studied organizations and according to the total average of agile supply chain (3.85) and lean supply chain (3.84) as well as the importance weight of the two types of supply chains, the final calculated index is equal to 3.847 which represents excellence of establishment of Leagile supply chain in industries and organizations.

Conclusion

Lean and agile supply chain improvement in the companies is achieved once the companies are able to respond to customer changes at minimum cost and waste. Lean supply chain results in increased profit by reducing costs, while agile supply chain through precisely meeting the customer needs, increases the profits. The main aim of this study is to provide an index to evaluate lean and agile supply chain of companies. The model presented in three organizations were reviewed and analyzed. In this regard, the behavior of the three studied organizations was evaluated on specified criteria. To test the presented model, according to the literature of study, some factors were selected as supply chain agility that their importance weight was obtained as follows:

1. The use of information technology and its distribution (9.2 percent)
2. The ability to change decisions based on market sensitivity (13.3 percent)
3. The focus and quality improvement in order to respond quickly to customer needs (12.8 percent)
4. Ability to make rapid changes in design and production of products (32.3 percent)
5. Flexibility in production and response to market volatility (8.6 percent)
6. The ability to change the delivery of products to customers (23.7 percent)

Similarly, effective standards on lean supply chain and their importance weight were calculated as follows:

1. Cost-cutting strategies (9.2 percent)
2. Minimum inventory and save on the purchase of raw materials (14.1 percent)
3. Ability of on-time Manufacturing (32.7 percent)
4. Proper and timely maintenance of machines (8 percent)
5. The error correction rate and standardization of work (35.9 percent)

Then according to the behavior of organizations in each of the eleven standards of above, and weighs of that criteria, the index of supply chain agility and leanness of organization were obtained. Results showed that, in general, the importance of agile supply chain with regard to the conditions in the industries and organizations is more than lean supply chain. Also organizations and industries should adopt appropriate approaches to the implementation of both strategies simultaneously to take advantage of the benefits of both strategies and have an efficient supply chain. The reason for this is that, lean strategy, expands a value flow from supplier to end customer and agile strategy means using market knowledge and the concept of a virtual company to exploit the lucrative opportunities in volatile markets. But the strategy of Leagile, is a combination of lean and agile strategies across an entire supply chain. Most of organizations and industries have come to the conclusion that in order to create an effective and efficient supply chain, they need to asses various fields and effective criteria on supply chain.

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