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Identification and ranking the factors affecting lean manufacturing by using FAHP technique (Case study of Iran Transfo Corporation)

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Abstract

In the second half of the twentieth century, global manufacturers faced with new competitors that with half of the necessary capital and facilities, supplied products to the global market with better quality, more variety and lower price. Despite the limitations in the market and thus the necessity of producing diverse products in small scale to meet diverse needs of customers, companies are forced to increase the production efficiency through continuous and uninterrupted effort to eliminate the dissipations. Lean manufacturing is one of the new techniques that arose from the automobile industry. The purpose of this research is to identify and rank the factors affecting lean manufacturing by using FAHP technique. This study in terms of applied objective and procedure is descriptive-analytic. The study population is Iran Transfo Corporation, in which by using the Cochran table, 145 people were determined as samples and were randomly selected, and through the questionnaire were evaluated. Pearson's correlation coefficient was used to investigate the relationship between independent and dependent variables, and Fuzzy Analytic Hierarchy Process (FAHP) was also used to rank the factors affecting lean manufacturing. The results of analysis of variables suggest that human resources, organizing, supply chain management, leadership, production process management and management information system have been effective on lean manufacturing, and leadership has been the most effective factor on lean manufacturing.

Keywords: Lean Manufacturing, Leadership, Supply chain management, Fuzzy Analytic Hierarchy Process

Introduction

Today's competitive environment has created many changes in organizations and production systems. Providing a new method for production in the industry is one of these developments, so we could offer products to consumer markets with better quality and more variety and lower prices and lesser production costs, so that by taking a larger share of the market, also witness more profitability for companies and organizations. Lean manufacturing is one of these methods. The birthplace of lean manufacturing is Toyota corporation in the island of Nagoya, Japan. In the 1950s, Eiji Toyoda with company engineer (Taiichi Ohno) traveled to America and visited Ford Motor Company and concluded that the principles of mass production are not implementable in Japan, because this system is full of dissipation. On this basis, they created a new method, which was later named “lean”. The main principles of lean manufacturing

thinking are GIS establishment, prevent the production of defective products, attention to the actual needs of customers, implementation of Kaizen principles in the factory and the expansion of communication within the set, and finally we can say that lean manufacturing is a proper method in the production process, which as mentioned has beneficial and positive effects for companies and organizations using it (Kalantari, 1382).

National Institute of Standards and Technology in the Ministry of Commerce of America has defined lean manufacturing as: "a systematic solution for identification and eliminating dissipations (activities that do not have value added) through continuous improvement and launching of correct production when customer needs it. This production philosophy seeks perfection and perfecting of production systems." Lean manufacturing also called by other names such as: "Fluent production", "Toyota production system", "Just-in-time production" (Johansson, 2004). In this method, a person tries to cut the manufacturing space, investment in equipment, engineering work hours and stagnant inventory into half and have a lot of attention to zero defect and zero inventory. In lean manufacturing method, manufacturers are looking to reduce the use of resources. In this method, work force used, the capital and installation of machinery, space needed for manufacturing, work warehouses, materials and products, engineering force and product design, all and all reduce in half and thus, designing, producing, distribution and sale of the products reduce in half and this is the goal of lean manufacturing (Farokh, 1382).

Lean manufacturing is creating a sense of responsibility in employees. Responsibility does not mean answering to higher authorities, but it means freedom at work. In this approach, employees have more challenges in the production process and therefore, they can manifest their own creativity more, and through teamwork, in addition to continuous improvement and continuous correction of system, they can acquire various skills.

Theoretical foundations of the research

This approach or thinking is called "lean" because it can provide a method, in which though it we can do the most of the work with the lowest (i.e. lesser manpower, lesser equipment, lesser time and lesser space), and at the same time by appropriate supply of customer needs, get close and closer to them (Womack and Jones, 1382). Shaffer et al (2012) have defined lean manufacturing as a production strategy that in fact considered as trail of mass production. This approach by focusing on reducing setup times of machine and changing the line for different processes, developing new ideas in the field of human resources and also advanced techniques in the field of quality, seeks to build a broader and more diverse range of vehicles demanded by Japanese market. This approach to achieve the above objective, has developed intelligent supply chains to supply the materials and factory parts. In addition to aforementioned chains, today a network of distributors and resellers in distribution and customer sectors have been also created at the same time.

The most important difference between mass production and lean production is the difference in their ultimate goals. The goal of mass producer is: "being good enough". In other words: "acceptable number of defects", the maximum acceptable level for inventory and certain range of same products are of the goals of a mass producer. Lean manufacturing philosophy is based on "perfection", which means continuous decline in prices, to zero the amount of defects, to zero the inventory and endless variety of products (Shah, 2009).

Dennis (2010) also introduced the goal of lean manufacturing as satisfying customer demands at the highest quality, the lowest cost and possible time by sustainable elimination of dissipations and achieving zero dissipation.

Melo and Stanek (2013) have specified a theoretical framework, that has an application for dimensions of organizational culture for succession of supply chain management in companies. According to their framework, supply chain management is more effective in companies that have honest and committed

employees and there is a proper cooperation between senior executives, and staff are supported. Although this situation is not directly related to lean manufacturing and JIT production, but one of the condition for successful strategy and lean thinking is the consistency in the supply chain. Therefore, cultural factors are very important and challenging.

Mac Carter et al. (2005) after examining 51 senior managers of a chain found out that administrators need an adequate understanding of different organizational roles for carrying out different activities; This allows more flexibility of organization and improves decision-making times.

One of the newest research about lean manufacturing belongs to Nestle company in England. In this research expressly has been referred to the complexities of implementing lean manufacturing process, and continuously improvement and correction of organizational culture have been declared as the most important factors in successful implementation and shifting towards becoming lean (Nakamura, 2013).

Another study that confirms the results of this research, has been conducted by Peter Murray, and represents the tremendous impact of training and teamwork in changing the nature, continuous improvement and correct implantation of TQM on lean manufacturing.

Research hypotheses

In this study, in order to achieve the purpose of research, hypotheses are put forward as follows:

1. The human factor influences lean manufacturing.
2. Organizing is effective on lean manufacturing.
3. The supply chain management affect lean manufacturing.
4. Leadership is effective on lean manufacturing.
5. Production process management influences lean manufacturing.
6. The management information system is effective on lean manufacturing.

Research methodology

The present research, experimentally is in positive research field and it is based on factual information. Also, regarding data collection in terms of time has survey approach and regardless of the goal is descriptive. Descriptive research includes collection of methods, which the researcher goal from this type of research is objective, factual and regular description of properties of a situation with a subject.

Survey research is a method that examines the nature of properties and personal perceptions (attitudes, belief, etc.) of people through question analysis and is the answer to questions that have been carefully edited. Given the nature of The present research, collecting data method is field study. In this research, the data collection is performed through reviewing and studying the records available in libraries or other information centers and also files and other information storage device.

Population and statistical sample

Usually in each study, the study population is a statistical population that researcher wants to study about its characteristic or its unit variable characteristics. In this study, statistical population is Iran Transfo Corporation.

If in sampling, the statistical population size would not be large, the whole population will be studied, but if the statistical population size would be large, sample would be introduced and then selected and finally the results from it would be generalized to the whole statistical population. In this research, first we will determine sample size by Cochran table and then we try to randomly select sample members.

Tests and statistical techniques

In this research, descriptive statics will be used for analyzing the data. Also, SPSS software will be used for analyzing the data obtained from questionnaires distributed. It is notable that, researcher is attempting to use a researcher-made questionnaire based on five-item Likert scale with closed question for collecting the quantitative data.

In inferential statistics of this research, Kolmogorov - Smirnov test will be used for examining the normality of variables, and in the case of normal variables, Pearson correlation coefficient will be used

for examining the relationship between independent and dependent variables. Also, Fuzzy Analytic Hierarchy Process (FAHP) will be used for ranking of variables. In this research, SPSS ver.16 will be used for analyzing the data from questionnaires used.

Dependability or reliability test of questionnaire

There are different and various methods for determining the measurement instruments reliability, internal consistency test is one of them. internal consistency of instruments can be measured by Cronbach's alpha coefficient. The coefficient for the questionnaire used for this study is as follows:

Table 1. Cronbach's alpha of factors for examining the reliability of the questionnaire

Cronbach's alpha	Measurement	FACTOR
0/921	5 point Likert	Human factors
0/789	5 point Likert	Organized
0/798	5 point Likert	Supply Chain Management
0/912	5 point Likert	Leadership
0/865	5 point Likert	Manufacturing Process Management
0/825	5 point Likert	Management Information System

As is evident in table (1), according to Cronbach's alpha coefficient obtained for the entire questions of the questionnaire and for each section of questions that relate to a specific factor, questionnaire reliability in total and for each section is at an acceptable level. Because, Cronbach's alpha coefficient obtained for all of them is higher than 0.7.

Examining the normality of research data

Kolmogorov – Smirnov test is used for checking the normality of research data. The test is a simple non-parametric method to determine data standardization with selected statistical distribution. The output of this test is a table, in which if Z static is less than 0.05 indicates that selected distribution for data is not appropriate, and vice versa.

Table 2. Kolmogorov – Smirnov test for examining normality of data

		Human factors	Organizing	Supply Chain Management	Leadership	Manufacturing Process Management	Management Information System
N		145	145	145	145	145	145
	Mean	3. 25	2. 68	3. 14	2. 85	3. 35	3. 20
	Std. Deviation	0. 78	0. 69	0. 71	0. 84	0. 75	0. 82
	Absolute	0. 091	0. 085	0. 087	0. 089	0. 102	0. 086
	Positive	0. 074	0. 082	0. 061	0. 081	0. 089	0. 08

Negative	-0. 084	-0. 074	-0. 083	-0. 064	-0. 075	-0. 058
Kolmogorov-Smirnov Z	1. 547	1. 154	1. 562	1. 143	1. 254	1. 186
Asymp. Sig. (2-tailed)	0. 085	0. 124	0. 073	0. 241	0. 094	0. 142

Functional testing shows that significant level of all research variables are greater than 0.05, therefore, the null hypothesis, which means hypothesis of normal distribution of research data, is confirmed.

Examining the correlation between research variables

According to the normality of data, we use Pearson correlation test. The purpose of this test is determine whether there are relationship and correlation coefficient between dependent and independent variables. The results are as follows:

Table 3. Pearson correlation test

		Human factors	Organizing	Supply Chain Management	Leadership	Manufacturing Process Management	Management Information System
Human factors	Pearson Correlation	1	0. 248**	0. 351**	0. 641**	0457**	0. 627**
	Sig. (2-tailed)		0. 001	0. 000	0. 000	0. 004	0. 000
Organized	Pearson Correlation		1	0. 528**	0. 632**	0. 745**	0. 547**
	Sig. (2-tailed)			0. 000	0. 000	0. 002	0. 000
Supply Chain Management	Pearson Correlation			1	0. 529**	0. 412**	0. 318**
	Sig. (2-tailed)				0. 000	0. 000	0. 000
Leadership	Pearson Correlation				1	0. 365**	0. 524**
	Sig. (2-tailed)					0. 001	0. 000
Manufacturing Process Management	Pearson Correlation					1	0. 634**
	Sig. (2-tailed)						0. 000
Management Information System	Pearson Correlation						1
	Sig. (2-tailed)						

Given that significant level calculated by Pearson test for all variables is less than 0.05, the null hypothesis is rejected. Thus, research variables at a confidence level of 99% have a positive and significant relationship.

Prioritize confirmed factors and variables by FAHP method

At this stage, paired comparisons questionnaire was prepared to prioritize the factors and variables, and it was distributed among 10 experts, who their opinions were used in the previous stage.

Respondents verbal comments about factor and variables are convertible to triangular fuzzy numbers, which are verbal scales for determining the weight of variables according to table (4):

Table 4. Verbal scales to express the importance of verbal factors (Nepal et al., 2010)

Reverse triangular fuzzy numbers	Triangular fuzzy numbers	Language measures to importance	
(1,1,1)	(1,1,1)	Exactly the same	Just Equal
$)\frac{2}{3},1,2($	$(\frac{1}{2},1,\frac{3}{2})$	Almost equal importance	Equally Important
$(\frac{1}{2},\frac{2}{3},1)$	$(1,\frac{3}{2},2)$	Relatively more	Weakly more important
$(\frac{2}{5},\frac{1}{2},\frac{2}{3})$	$(\frac{3}{2},2,\frac{5}{2})$	More important	Strongly more Important
$(\frac{1}{3},\frac{2}{5},\frac{1}{2})$	$(2,\frac{5}{2},3)$	Very importantly,	Very Strongly more Important

Calculating the weight vector of pairwise comparison matrices

Chang's extent analysis was used for calculating the importance weights of each element in pair comparison matrix. Based on this, matrix of expert's opinions aggregation was obtained according to table (5) and from the geometric mean of triangular fuzzy matrix of expert's opinions (10 collected questionnaires) about the factors affecting lean manufacturing.

Table 5. Matrix of expert's opinions aggregation about the factors affecting lean manufacturing

Management Information System	Manufacturing Process Management	Leadership	Supply Chain Management	Organizing	Human factors	Criteria
(8 .0 2 .1 6 .1)	(5 .0 7 .0 9 .0)	(8 .0 1 .1 7 .1)	(4 .1 8 .1 4 .2)	(7 .0 1 5 .1)	(1 1 1)	Human factors
(1 .1 5 .1 9 .1)	(8 .0 1 .1 4 .1)	(7 .0 1 3 .1)	(6 .0 7 .0 9 .0)	(1 1 1)	6 .2 2) (2 .1	Organized
(5 .0 7 .0 9 .0)	(7 .0 1 4 .1)	(1 .1 5 .1 9 .1)	(1 1 1)	(7 .0 1 3 .1)	7 .0 9 .0) (6 .0	Supply Chain Management
(2 .1 6 .2 1 .2)	(8 .0 1 .1 6 .1)	(1 1 1)	(3 .1 7 .1 3 .2)	(7 .0 9 .0 2 .1)	7 .1 2 .2) (3 .1	Leadership
(7 .0 9 .0 2 .1)	(1 1 1)	(7 .0 1 3 .1)	(8 .0 1 4 .1)	(1 .1 4 .1 7 .1)	7 .1 1 .2) (3 .1	Manufacturing Process Management
(1 1 1)	(5 .0 6 .0 8 .0)	(5 .1 6 .0 8 .0)	(6 .0 8 .0 2 .1)	.0 6 .0 8 .0) (4	5 .0 7 .0) (4 .0	Management Information System

In the following, we calculate fuzzy synthetic extent of each factors:

After obtaining fuzzy synthetic extent value, we calculate degree of possibility for each possible binary mode according to Table (6), and we obtain minimum degree of possibility for each factor compared to other factors, so weighted vector for each factor is achieved.

Table 6. The possibility degrees for any possible binary mode of the factors affecting lean manufacturing

Table 7. The importance degrees of the factors affecting lean manufacturing

Factors	Human factors	Organizing	Supply chain management	Leadership	Manufacturing process management	Management Information System
Minimum degree of possibility	0.846	0.782	0.758	0.924	0.842	0.682
The final weight	0.175	0.162	0.157	0.191	0.174	0.141

Conclusion

Lean manufacturing by focusing on identification and elimination of dissipation in organization has impressive results in improving quality, increasing flexibility, reducing costs and improving productivity, efficient use of manpower and machinery and equipment and improving on-time delivery and etc., and it has been proposed as a continuous improvement mean in leading companies. Lean organization is developing lean production idea in whole organization and even beyond the borders of the organization, in such a way that value would be created for all stakeholders, and this requires that all action and operations should be done as lean. Lean organization creates value for its stakeholders by focusing on the whole organization (human resources, organizing, supply chain management, leadership, production process management and management information system).

Lean manufacturing is an approach, which aims to eliminate any non-value processes from preparation of raw materials stage until sales, which does not create added value for the customer. Close relationship with the supplier based on reasonable profit, constant contact with customer by database system and mutual commitment between management and the employees are of features of this system.

In this research, we examined the relationship between factors affecting lean manufacturing in Iran Transfo Corporation. The research findings suggest that six groups of human factors, organizing, supply chain management, leadership, production process management and management information system have been effective on lean manufacturing and leadership had the greatest effect on lean manufacturing. While, human factors, production process management, organizing, supply chain management and management information system were respectively in the next rankings affecting lean manufacturing.

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