Lean service scale: developing and validating a scale

Farzad Movahedi Sobhani, Zahra Gharib, Zahra Esfandiary

***Abstract*— Despite the growth of the service sector in the global economy and extensive research in the field of Lean but there isn't an appropriate scale for the measurement of Lean service. Lean is making a transition from the manufacturing sector to the public sector because Lean management promises to eliminate waste, reduces costs, and improves product or service quality.**

The purpose of research presenting a scale for measuring lean service that included five steps: pilot items, measurement of expert validity, Extraction of factors via EFA, Confirmation of extracted factors via CFA and determine reliability. Lean Service Scale (LSS) included 27 items in six dimensions: lean structure, lean inventory, lean Maintain and Repair (MR), lean movement and lean staff.

***Index Terms*— lean thinking - Principal components analysis – service management.**

I. INTRODUCTION

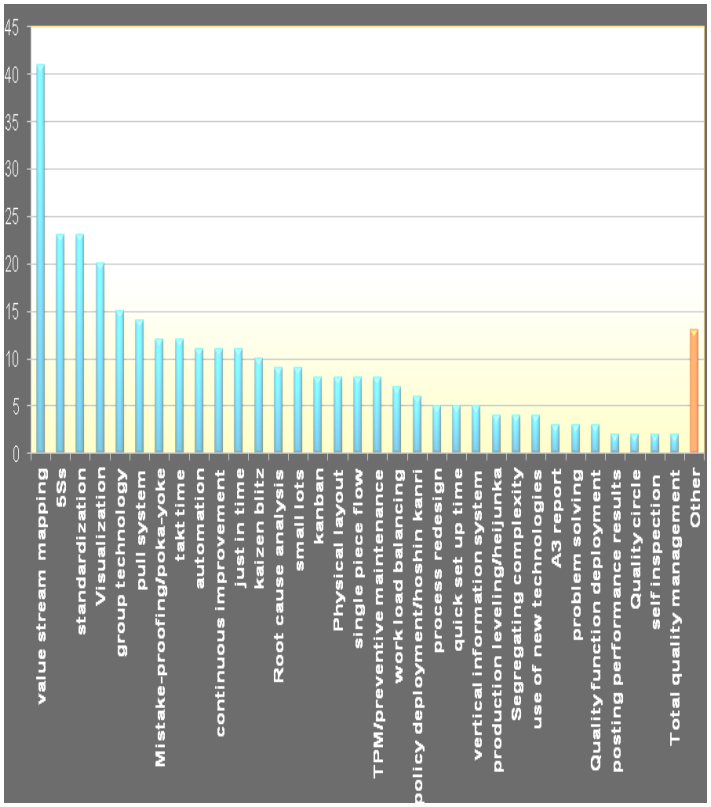
In recent years, Globalization accompanying with increasing competition have forced companies to seek new production and management systems that eliminate waste and control costs [1]. that Lean System is one of those cases.

The term lean was not coined till the 1990s. Lean manufacturing is a philosophy that considers the expenditure of resources for any process that doesn't add value to the final customer as a non-value added process and hence is a waste that has to be eliminated from the system [2].

Lean theory is rooted in the scientific method and the Plan-Do-Check-Act (PDCA) cycle originally developed by Walter A. Shewhart, a Bell Laboratories scientist who was Deming's friend and mentor. Lean thinking helps define both what has to be done to solve a problem and how work is performed [3].

Lean system is an approach focusing on eliminating non-value-added activities from processes by applying a robust set of performance change tools, and emphasizing excellence in operations to deliver superior customer services [4].

Lean production encompasses a wide variety of practices or tools including just in time, total quality management, total productive management, kaizen etc. but Today, lean tools are not solely for use by the manufacturing industry, more organizations in the service sector such as healthcare and telecommunications etc. are adopting lean tools in order to streamline services and reduce time spent on non-value added activities. [2] that Figure 1 reveals that several lean techniques invented in manufacturing are becoming popular in services. Several researchers argue that lean tools and techniques are interrelated and complementary [5].



Lean program described as a success key inside of an company and its implementations can bring amazing results after only a few years that many benefits among them we enumerate the most important ones: efficient use of resources, rapid product development cycle, higher quality at lower cost, greater flexibility, and environmentally sustainable production[6].

Through several authors attempted to examine the validity of lean to services but there is yet a strong lack of scale for measuring lean service so the aim of the study is to develop scale for measuring lean in service sectors.

II. LITERATURE REVIEW:

A. Lean service:

The perspectives of Lean are very much depending upon the industry, the source, how long the organization has been learning about Lean, and what that organization's real objectives are for adopting Lean[6].

From viewpoint of some researchers, Lean system is perceived to consist of two levels: lean philosophy and lean practices while to others it is a three-level system, lean

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Farzad Movahedi Sobhani Department of industrial engendering, science and research, Islamic Azad University, Tehran

Zahra Gharib Department of industrial engendering, science and research, Islamic Azad University, Tehran, Iran

Zahra Esfandiary Department of industrial engendering, science and research, Islamic Azad University, Tehran, Iran

philosophy, lean principles and lean practices [5]. that shown in table1.

Levels	***Descriptive***
lean philosophy	focuses on improving the value from customer perspective by eliminating waste from processes
lean principles	involves the five principles introduced by Womack and Jones (1996) which are a roadmap to achieve the first level
lean practices	is necessary to reflect the previous two levels practically and subsequently, it represents the actions to be taken

Table (1): Lean system levels

Lean is basically all about getting the right things to the right place, at the right time, in the right quantity while minimizing waste and being flexible and open to change. As it stands the method is resultfull, comparatively with the investments, but as it involves all employees all of these concepts have to be understood, appreciated and embraced by them. Being directed for performance, lean is the way for the continuous growth of a business [6].

Lean approaches help managers recognize and reduce the waste in processes. Wastes are activities that add no value from a customer perspective, including [7]:
Waiting—waiting for the next event to occur or next work activity
Motion—unnecessary movement by employees in the system
Transportation— unnecessary movement of the product in a system (patient, specimens, materials)
Defects—time spent doing something incorrectly, inspecting for errors, or correcting errors
Over processing—doing work that is not valued by the customer or caused by definitions of quality that are not aligned with patient needs
Overproduction—doing more than what is needed by the customer or doing it sooner than needed

In the following, Munteanu and Olteanu (2007) will summarize an example of a lean implementation program. The main steps would be:
1. Senior management to agree and discuss their lean vision;
2. Management brainstorm to identify project leader and set objectives;
3. Communicate plan and vision to the workforce;
4. Ask for volunteers to form the Lean Implementation team (5-7 works best, all from different departments);
5. Appoint members of the Lean Manufacturing Implementation Team;
6. Train the Implementation Team in the various lean tools - make a point of trying to visit other noncompeting businesses which have implemented lean;
7. Select a Pilot Project
8. Run the pilot for 2-3 months - evaluate, review and learn from your mistakes;
9. Roll out pilot to other factory areas;
10. Evaluate results, encourage feedback; Once you are satisfied that you have a habitual program; consider introducing the next lean tool. Select the one which will give you the biggest return for your business[6].

B. Factor analysis:

In many instances, researchers are interested in variables that cannot be directly observed, such as achievement, intelligence, or beliefs. In research methodology, authors use terms such as latent variables or factors to describe unobserved variables. They attempt to gain information about latent factors through observable variables. Factor analysis is statistical technique that one can use [8].
While factor analysis has origins dating back 100 years through the work of Pearson and Spearman, the practical application of this approach has been suggested to be in fact a modern occurrence [9].
Factor analysis is a multivariate statistical procedure that has many uses, three of which will be briefly noted here. Firstly, factor analysis reduces a large number of variables into a smaller set of variables (also referred to as factors). Secondly, it establishes underlying dimensions between measured variables and latent constructs, thereby allowing the formation and refinement of theory. Thirdly, it provides construct validity evidence of self-reporting scales [9].

There are two major classes of factor analysis: Exploratory Factor Analysis (EFA), and Confirmatory Factor Analysis (CFA). In EFA, the investigator has no expectations of the number or nature of the variables and as the title suggests, is exploratory in nature. That is, it allows the researcher to explore the main dimensions to generate a theory, or model from a relatively large set of latent constructs often represented by a set of items[9].
CFA is a confirmatory technique—it is theory driven. Therefore, the planning of the analysis is driven by the theoretical relationships among the observed and unobserved variables. When a CFA is conducted, the researcher uses a hypothesized model to estimate a population covariance matrix that is compared with the observed covariance matrix. Technically, the researcher wants to minimize the difference between the estimated and observed matrices [8]. in fact, in CFA the researcher uses this approach to test a proposed theory (CFA is a form of structural equation modeling), or model and in contrast to EFA, has assumptions and expectations based on priori theory regarding the number of factors, and which factor theories or models best fit[9].

III. METHODOLOGY:

As we said, the main objective of research is development and validation a scale for measurement lean service. Therefor the researchers follow five steps:
Step1: items pool
Step2: measurement of expert validity
Step3: Extraction of factors via EFA
Step4: Confirmation of extracted factors via CFA
Step5: determine reliability

In first step, for determination of initiative items, we study different articles and books in field of lean that two major sources include Liker (2004)[10] and AlemTajbriz (2009)[11].
According to Liker (2004)[10] there are eight major types of non-value-adding activities in business or manufacturing

processes identified, included: Overproduction , Waiting (time on hand), Transportation or conveyance, Over processing or incorrect processing, Excess inventory, Unnecessary movement, Defects and Unused employee creativity. Liker (2004)[10] points out that the application is also valid for other processes other than manufacturing processes, such as information or service processes. Also, AllemTajbriz (2009)[11] noted that other three important wastes can exist in organizations that included: Environmental waste, maintenance and repair (M.R), Organizational problem. In the step was prepared 87 items as pilot items.

For measurement of expert validity is used CVR that was developed by C. H. Lawshe. Lawshe (1975)[12] provided a table of critical values for the CVR by which a test evaluator could determine, for a pool of the subject matter expert raters (SMEs) of a given size, the size of a calculated CVR necessary to exceed chance expectation. CVR before hitting its ceiling value at the case of 7 SMEs is minimum value = .99. in the research is used five experts that eliminated 29 items.

For Extraction of factors via EFA (step3), 58 items setting out the form of a questionnaire and distributed in the ports and maritime organization (PMO) Margin of Caspian Sea in Iran.

In this research, from 187 questionnaires that had been distributed in the ports and maritime organization (PMO) Margin of Caspian Sea in Iran., 13 of them (6.95 %) hadn't been returned, 6 of them (3.20 %) weren't completed and 98 of them were completed that were ready for analyzing a rate equal with 89.84 % that is a good rate. The samples of 98 respondents were 92.9 percent male and 7.1 percent female, and most of them were below 40 year of age.
In step 4, PLS Smart software used for Confirmation of extracted factors via CFA that the results shown in next section. Finally, Alpha Cronbach examined for determination of reliability via SPSS19.

Findings:

This stage, after validating of Experts and obtain 58 items, is Extraction of factors via EFA by using SPSS 19. Exploratory Factor Analysis includes four steps:
Step 1: Is the data suitable for factor analysis?
Before doing Factor analysis, should be done items purification that is used from Corrected Item-Total Correlation (CITC) are used. If the items value was less than 0.3 must be eliminated from the analysis. According to the results from the 54 items, 8 items will be removed. To ensure first whether factor analysis in this study is permitted and fit there or not sampling, KMO and Bartlett's Test of Sphericity was calculated. The KMO index ranges from 0 to 1, with 0.50 considered suitable for factor analysis. The Bartlett's Test of Sphericity should be significant (p<.05) for factor analysis to be suitable [8].

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.727
Bartlett's Test of Sphericity	Approx. Chi-Square	8288.161
	df	1431
	Sig.	.000

Table (2): the results of Measure of Sampling Adequacy

Step 2: How will the factors be extracted?

Principal components analysis (PCA) used for extraction factors because some researchers suggested using PCA in establishing preliminary solutions in EFA [13].
The aim of rotation is to simplify the factor structure of a group of items, or in other words, high item loadings on one factor and smaller item loadings on the remaining factor solutions.

For Recognizing the contribution of factors in explaining the variance of each item is used eigenvalues that if item was eigenvalues less than 0.3, so that option will be removed from the exploratory factor analysis, the next step will be. In the research any items wasn't less than 0.3.

item	Extraction	item	Extraction	item	Extraction
s2	0.74	s19	0.713	s40	0.739
s4	0.718	s21	0.685	s41	0.68
s5	0.727	s22	0.725	s42	0.713
s6	0.767	s23	0.683	s43	0.753
s7	0.751	s24	0.723	s44	0.68
s8	0.57	s25	0.638	s46	0.823
s9	0.823	s26	0.627	s47	0.813
s10	0.743	s27	0.773	s48	0.764
s11	0.82	s29	0.653	s49	0.773
s12	0.736	s31	0.621	s50	0.766
s13	0.742	s32	0.76	s51	0.774
s14	0.704	s34	0.761	s52	0.685
s15	0.738	s35	0.824	s53	0.751
s16	0.707	s36	0.683	s54	0.848
s17	0.738	s37	0.788		
s18	0.71	s38	0.805		

Table (3): the contribution of factors in explaining the variance of each item

Step 3: What criteria will assist in determining factor extraction?
The aim of the data extraction is reduce a large number of items into factors. In order to produce scale unidimensionality, and simplify the factor solutions several criteria are available to researchers. One of the extraction rules include Kaiser's criteria that should eigenvalue > 1. In the research a total of 10 components (factors) having an eigenvalue >1

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	14.779	32.129	32.129	14.779	32.129	32.129	5.649	12.281	12.281
2	4.699	10.215	42.344	4.699	10.215	42.344	5.575	12.121	24.402
3	3.092	6.723	49.066	3.092	6.723	49.066	5.018	10.908	35.310
4	2.395	5.207	54.274	2.395	5.207	54.274	4.294	9.334	44.644
5	2.249	4.889	59.163	2.249	4.889	59.163	2.701	5.871	50.515
6	1.622	3.525	62.688	1.622	3.525	62.688	2.676	5.817	56.333
7	1.355	2.946	65.635	1.355	2.946	65.635	2.286	4.969	61.302
8	1.302	2.830	68.464	1.302	2.830	68.464	2.177	4.732	66.034
9	1.157	2.516	70.980	1.157	2.516	70.980	1.818	3.951	69.985
10	1.107	2.406	73.386	1.107	2.406	73.386	1.565	3.401	73.386

Table (4): Total Variance Explained

Step 4: Selection of Rotational Method:
Another consideration when deciding how many factors you will analyses your data is whether a variable might relate to more than one factor. Rotation maximizes high item loadings and minimizes low item loadings, therefore producing a more interpretable and simplified solution. The research is used Varimax with Kaiser Normalization.

	Component						
	1	2	3	4	5	6	9
Item8	0.543						
Item21	0.446						
Item32	0.488						
Item41	0.595						
Item43	0.697						
Item49	0.649						
Item50	0.813						
Item51	0.798						
Item52	0.528						
Item53	0.672						
Item54	0.66						
Item6		0.625					
Item7		0.701					
Item11		0.751					
Item19		0.663					
Item24		0.493					
Item25		0.703					
Item27		0.696					
Item44		0.509					
Item12			0.686				
Item13			0.768				
Item14			0.717				
Item15			0.78				
Item16			0.629				
Item17			0.503				
Item18			0.547				
Item 37			0.727				
Item 38			0.769				
Item40			0.306				

Item5				0.773			
Item26				0.624			
Item29				0.462			
Item46				0.791			
Item47				0.794			
Item48				0.73			
item4					0.531		
Item23					0.418		
Item34					0.556		
Item42					0.723		
Item9						0.584	
Item10						0.759	
Item22						0.618	
Item31						0.446	
Item32						0.484	
Item2							-0.711
Item35							0.629
Item36							0.533

Table (5): Rotated Component Matrix

For determining validity, convergent validity was assessed for all indicators. For this purpose is applied from confirmatory factor analysis (CFA) by using PLS Smart. Factor loadings should were higher than 0.7. The results of factor loadings shown in table (5). From remaining 47 items, 19 items were eliminated.

	1	2	3	4	5	6	9
Item8	0.646						
Item21	0.716						
Item32	0.689						
Item41	0.608						
Item43	0.696						
Item49	0.811						
Item50	0.814						
Item51	0.711						
Item52	0.675						
Item53	0.749						
Item54	0.813						
Item6		0.736					
Item7		0.836					
Item11		0.803					
Item19		0.791					
Item24		0.671					
Item25		0.738					
Item27		0.823					
Item44		0.540					
Item12			0.808				
Item13			0.738				
Item14			0.686				
Item15			0.839				
Item16			0.756				
Item17			0.742				
Item18			0.696				
Item 37			0.518				
Item 38			0.486				
Item40			0.531				
Item5				0.550			
Item26				0.676			
Item29				0.731			
Item46				0.813			

Item47				0.845			
Item48				0.791			
item4					0.661		
Item23					0.797		
Item34					0.893		
Item42					0.732		
Item9						0.642	
Item10						0.769	
Item22						0.865	
Item31						0.759	
Item2							0.306
Item35							0.659
Item36							0.855

Table (6): The results of confirmatory factor analysis (CFA) by using PLS Smart software

For determining reliability of the scale in this research, used Cronbach's alpha. Total Cronbach's alpha was 0.939 .So the questionnaire reliability is acceptable. Only thirty six item eliminated because Cronbach's Alpha is increased if the item Deleted.

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Items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	***Cronbach's Alpha if Item Deleted***
S21	78.2917	288.615	.688	***.935***
S49	78.4167	283.909	.682	***.935***
S50	78.3333	293.505	.534	***.937***
S51	78.3929	300.096	.425	***.938***
S53	78.1548	292.012	.549	***.937***
S54	78.2143	284.577	.653	***.936***
S6	78.1786	293.333	.577	***.937***
S7	78.0417	289.441	.720	***.935***
S11	78.0357	287.819	.642	***.936***
S19	78.1071	288.899	.686	***.936***
S25	77.9821	292.221	.544	***.937***
S27	77.9345	285.930	.713	***.935***
S12	78.2917	292.004	.538	***.937***
S13	78.6964	298.991	.388	***.939***
S15	78.7083	296.136	.503	***.938***
S16	78.3631	298.891	.392	***.939***
S17	77.9821	287.838	.664	***.936***
S29	78.6190	293.004	.564	***.937***
S46	78.1905	292.047	.542	***.937***
S47	78.3333	295.529	.526	***.937***
S48	78.0536	294.171	.556	***.937***
S23	78.2440	290.461	.639	***.936***
S34	78.4464	290.141	.714	***.935***
S42	78.2381	293.823	.520	***.937***
S10	78.4286	297.085	.488	***.938***
S22	78.6071	292.923	.621	***.936***
S31	78.4345	290.606	.606	***.936***

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S22	78.6071	292.923	.621	***.936***
S31	78.4345	290.606	.606	***.936***
S36	78.5833	298.221	.466	***.942***

Table (7): the results of Cronbach's Alpha

IV. CONCLUSION

Lean management has been applied across many different sectors and organizations and todays Lean is making a transition from the manufacturing sector to the public sector because Lean management promises to eliminate waste, reduces costs, and improves product or service quality [14]. Despite the growth of the service sector in the global economy and extensive research in the field of Lean but there isn't an appropriate scale for the measurement of Lean service. After doing 5 Steps in the ports i maritime organization, derived scale is consists of 6 dimensions and 27 items. A brief description of each of the factors is given below.

Factor1- lean processing: Included items that increase the speed of doing task to provide services. The amount of explained variance (12.281) was maximum amount among other factors. Lean processing included:

-To use scientific and effective methods for organizing office, place of teams, equipment, tools and stocks
-Mechanized the office operations, to avoid the slow handling process of customer affairs environmental and sound pollution ... at office
-The tendency of organization to resolving the different kinds of sound pollution
-Speed of repairing and rebuilding the faulty equipment
The tendency of staffs to mechanize the operations in the organization-
-The tendency of organization to remove the obstacle instructions

Factor2- lean structure: included Factors that are related to organizational structure in order that different sectors could do activities better. Six items of lean structure included:
To provide the ways of staff's job promotions-

-Contributing the results of analyzing employee morale in strategic plan scientificlity and systematically.
-provide appropriate rewards for good and applicative ideas
-to ensure the rapid implementation of ideas by agencies
-fit between salaries and incomes of staffs accordance with type of their activity
-performing unnecessary handling by workers or more ordinary equipment instead of using special and more advanced equipment

Factor3- lean inventory: Set of factors included to get better warehousing and inventory management. lean inventory included five items :
-Sorting and queue up the goods in warehouses based on certain principles
-Counting and delivery of goods systematically during deliver them to a public warehouse (open-closed)
-The timely delivery of goods from warehouses and access to them at the time desired by customers
-The amount of not damaging (staying safe) goods in warehouses, based on current styles
- To reconsider the wrapping (packaging) in case of failure of goods packing in.
Factor4- lean Maintain and Repair (MR): Factors that caused Maintain and Repair to be done properly up to avoid duplication.
-Choosing the right type of employed equipment for correct loading - unloading
-Accuracy in repairing damaged equipment to avoid duplication
-monitoring and regular inspection of equipment to prevent failure
-Control of unnecessary traffic in the range of operational agencies
Factor5- lean movement: Including transportation between parts and reducing the waiting time is.
-To avoid unnecessary goods transportation (between warehouses and pier)
-To Observe the distance between the place of loading goods (dock) to the unloading location (warehouse)
-To use flexible equipment (multi-purpose) to avoid time using.
Factor6- lean staff: Including factors related to employees to determine to what extent they have the ability and motivation to reduce waste. The amount of explained variance was minimum amount among other factors (5.817).
-To rebuild and make more speed in port's operations accordance with current facilities
-Notice to customers, priorities and needs of customers in the services that offer by staffs
-The tendency of staffs to eliminate destruction in the system

One of limitation to this study should be noted is scale generalizability. The sample, which seemed appropriate for this particular study, was in Caspian Sea margin, Iran. Therefore suggest future researchers that use and apply Lean Service Scale in other service organizations in different countries.

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