A mathematical model to auditing leanness by competitive benchmarking in an Iranian automaker

Abbas Toloie- Eshlaghy[1] and Majid Kalantary[2]

[1]Department of Industrial Management, Science and Research Branch, Islamic Azad University, Tehran, Iran
[2]Department of Industrial Management, Tehran University, Tehran, Iran.

ABSTRACT

Despite all the "talk" of lean production, it is obvious that many manufacturers have yet to grasp the full benefits of this philosophy, the strong weapon what Japanese used it to overcome American (and the other strong economies) giant organizations. So many organizations like to know their organization how far from lean standard benchmark system, and fill these gaps. The main goal of this research that is a competitive benchmarking, is introduction a simple mathematical model to shows positions of an Iranian automaker relative to Toyota, and helps them to calculate the size of their gaps between them and lean benchmark (Toyota).

Introduction

The term "Lean Production, LP" which introduced by three chief officers of The International Motor Vehicle Program (IMVP), in fact, has shown Toyota Production System, TPS. Therefore, for finding what LP is, we should back to few years ego, refer to 1950. Although, nowadays it is clear that there shouldn't be waste and should remove all of them, but this important concept came in to Toyota's managers mind and become the starter of a giant change in world industries.

In World War II, Japanese started the war against Americans, but finally they weren't the winners. By inventing a new weapon after war, Japan attacked to USA and other countries again, of course softly, but this time, they were the winners.

Their new weapon was Lean Production that is the new and Japanese version of American mass production. The Toyota production system (TPS) is at the heart of Toyota's manufacturing excellence.

The TPS is commonly called Lean Production (LP) or simple Lean by other industries (Muir, 2007). With its focus on removing the waste in current systems, concentrating on added value that customers pay for and improving product flow, to increase productivity and reduce lead times, lean is seen as representing a clear way forward for all of those looking to effectively face the increasing challenge posed by the low cost economics (Lee-Mortimer, 2006)

Japanese experience proved that use of TPS or LP can result in huge leap in organization and guarantees profitability, so this is a good reason for organizations to be lean.

For being lean, first we should know some factures. First the organization current condition and position (performance) is, and second, how far it is to a lean organization.

One of the main goals of this research is to find a way to calculate distance between any organization and the lean organization (benchmark organization). So a simple mathematical model is introduced for finding these gaps.

Literature review

Since the concepts "LP and TPS" were borne, every one has noted principles and attributions for them.

It may be said the authors of the book "The machine that changed the world" were the pioneers (Womack, 1990). They have noted some principles in the book "Lean Thinking" (Womack, 2003).

The book Lean Thinking, addressed the question of how to achieve the results shown by Toyota. It showed a series of tools for implement and general guidelines for setting up LP environment. Their five step approach is to:
• Specify value by specific product.
• Identify and map the value stream for each product.
• Make value flow without interruption.
• Let the ultimate consumer "pull" value from the manufacturer.
• Continuously pursue perfection.
In the other idea, the TPS is summarized in fourteen principles (Liker, 2005):
• Management decisions should be based on long-term philosophy even at the expense of short-time financial goals.
• Create continuous process flow to bring problems into goals.
• Use "pulls" systems to avoid overproduction.
• Level out the workflow.
• Build the culture of stopping to fix problems and eliminate reworks.
• Standardize tasks to facilitate predictability.
• Use visual control systems to make problems visible.
• Use reliable technology that serves your people and processes.
• "Grow" leaders who understand the work and philosophy, and teach it to others.
• Develop exceptional people and teams.
• Respect your extended network of partners and suppliers challenging and helping them.
• Go and see the process yourself to thoroughly understand.
• Make careful, informed decisions slowly consensus; implement rapidly.

Tele:
E-mail addresses: toloie@gmail.com,majidkalantary.pm@gmail.com

• Become a learning organization through continuous improvement.

Witnessing a lean process, an outsider may remark, "What's so special about that, it looks so simple?" Of course it is. Nothing could be simple than lean. But the Olympic athletics make their actions look simple only after years of practice, focused on a single goal: eliminate of all wasteful motions (Steve, 2006). It is truly looks like to lean production. Although lean production is minor, lean enterprise is major and overall business philosophy. The key point in achieving lean production is that firms must learn to view the process of managing as a total inter-firm system solution within entire production chains and not as a collection of independent techniques applied in independent companies (Soderquist, 1999).

One way in which organization may innovate and learn, as they respond to their competitive environment, is by means of benchmarking (Spendolini, 1992). In recent years, benchmarking has become a part of the business lexicon. Since the trend with regard to competitive pressures is expected to continue in the coming years, many companies, both large and small, will be more inclined to employ benchmarking as a part of the continuous improvement process (Yasin,1995). Three basic types of benchmarking are currently utilized: internal, competitive and functional (or generic) benchmarking. The process is essentially the same for each. The difference lies with what is to be benchmarked, and with whom it will be benchmarked. All are potentially beneficial in an organization's search for best practices. The process of benchmarking can be shown as this:
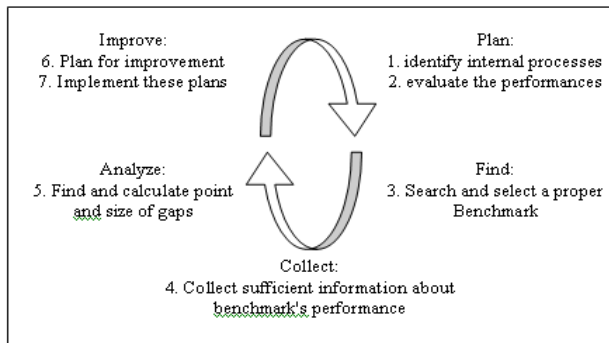

Figure 1: The benchmarking process's circle

Methodology

Achieving to a simple mathematical model for benchmarking and to compare an organization with a standard strong leader benchmark organization, can help organization to compare itself with others and to control its process each time.

Some hypothesizes have been suggested in this research. For rejection or not those hypothesizes by model, a conceptual model has been suggested that is shown in figure 2.
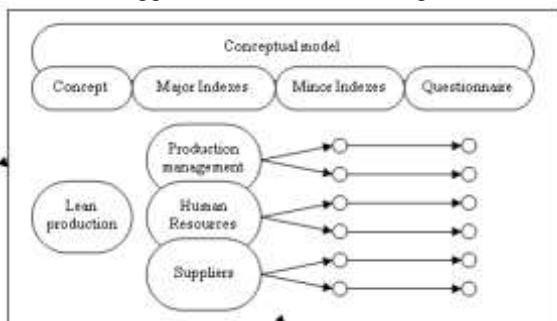

Figure 2: conceptual model

The theorem fundamentals of conceptual model are based on basic principles of lean production those have been mined from literature of lean production. These principles are noted in next section along with their weights in table 2. Suggested model is shown below:

$$PI = {}_w\sqrt{\prod_{i=1}^{n}\left(\frac{X_i}{Y_i}\right)^{w_i}}$$

$$W = \sum_{i=1}^{n}|W_i|$$

Where:

PI: organization performance index

X_i: value of criteria "i" in this organization.

Y_i: value of criteria "i" in benchmark organization.

W_i: relative ratio or weight of criteria "i".

W: summation of absolute ratios or weights

The advantages of this model are:

• Simple to use

• Not also compare two alternatives, but computes size of gap.

• Combination of negative and positive criteria simultaneously.

We can account this model as a technique of "compensatory models". This mode is explained in a simple example. We suppose a company compares itself with a leader organization based on three criteria and computes percentages closets.

For negative criteria (lower score, higher satisfy), it is used a negative mark for weights or ranks in model. So we have:

$$PI = \sqrt[1]{(90/99)^{0.3}(20/18)^{-0.3}(3/2)^{0.25}(11/4)^{-0.15}} = 0.8953$$

$$PI = 0.8953 \times \%100 = \%89.53$$

Result shows our organization performances are 10.47% far from our benchmark.

Information gathering

Related information is necessary to prove hypothesizes. We classified information in two categories, because the parameters of model required deferent information. Those categorizes are: 1) value of criteria, and 2) weight of each criteria.

We used questionnaires to information gathering. Value of each criterion has been measured by questionnaires those were filled by managers, engineers and technicians. They related closely and directly to line production in an Iranian automaker that has made and assembled CKD's from the PEJOUT Company.

The other questionnaires were distributed between professors and researchers who had experience in lean. The structure of these questionnaires (both categories) was been on "Interval Bipolar- Scale".

Information analysis

First step, after information gathering, was computation of criterions weights. For this mean, and combination of researchers priorities about each criteria's weight, it was used "Group Analytical Hierarchy Process, Group AHP". The Group AHP model is:

$$DM: \begin{array}{c|ccccc} & X1 & \dots & Xj & \dots & Xm \\ \hline X1 & a_{11} & \dots & a_{1j} & \dots & a_{1m} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ Xi & a_{i1} & \ddots & a_{ij} & \ddots & a_{im} \\ \vdots & \vdots & \dots & \vdots & \ddots & \vdots \\ Xn & a_{n1} & \dots & a_{nj} & \dots & a_{nm} \end{array}$$

$$a_{ij} = \sum {}^{wl}\sqrt{\prod_{l=1}^{k} a_{ijl}^{wl}}$$

DM: combination priorities matrix

a_{ijl}: priority of criterion "i" related to criterion "j" by researcher "l".

K: number of researchers who filled the questionnaires

W_l: relative importance of researcher "l" idea for us.

Calculation of weights was done by "Expert Choice, EC" (specific software that has designed for calculation of weights based on AHP). Results are shown in tables 2 and 3:

Values of standard benchmark organization were performance of Toyota Company, because Toyota was the pioneer in use lean principles. The values were extracted from documentations that were publicized by Toyota or others. Performance indexes for this organization are:

$$Pi_{suppliers} = 0.73 \text{ or } \%73$$
$$PI_{human\ resourses\ management} = 0.35 \text{ or } \%35$$
$$PI_{production\ management} = 0.35 \text{ or } \%35$$

And performance index of organization:

$$PI_{organization} = 0.42 \text{ or } \%42$$

Results show this organization has long distance to lean principles in production management and human resources management that results in big gap in organization PI. Based on results, organization must start modification programs from these two points.

Conclusion

To be leanness is not a common manner to strike a poses, but it is an ideal solution to survive and to eliminate all waste and wasteful actions. A simple model that can help organizations to know where they stand, and shows them the start point to modification programs urged us to present a model like that. We tried all our best to introduce a simple model to benchmarking and summarized lean principles and computed their weights. This research needs to be followed and to be used the other criterions such as accounting, marketing and strategic planning. In the other hand, other property mathematical models can be presented.

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Table 1: scores of both organizations in criterions

	Quality (%)	Cost ($)	Delivery (times in week)	Delay (hr)
Our organization	90	20	3	11
leader	99	18	2	4
weights	0.3	-0.3	0.25	-0.15

Table 2: sub-criterions and their calculated weights

criteria	Sub-criteria	weight	Sub-critera	weight	IR
Production Management	1. robotic system	0.044	4. CAM/ CAD	0.087	
	2. small multi-purpose machines	0.015	5. pull system (kanban)	0.208	
			6. quality circles	0.092	0.05
	3. total preventative maintenance	0.098	7. small batch production	0.32	
			8. u shape layout	0.042	
			9. decrease setup time	0.092	
Human resources Management	1. participation in Programs	0.042	5. self- discipline	0.06	
	2. continuous and Necessary training	0.074	6. self-evaluation workers	0.101	0.1
	3. team working	0.06	7. participation in Decision making	0.257	
	4. multi-skills workers	0.148	8. take an interest in Success of company	0.257	
suppliers	1. close relationship with suppliers	0.207	4. technical co working	0.064	
	2. long-term contract And few suppliers	0.06	5. high quality materials	0.496	0.06
			6. lower distance	0.028	
	3. buy small batch	0.031	7.price consistency	0.115	

IR: Inconsistency Ratio

Table 3: Main criterions and their calculated weights

Main criterions	weights
Production Management	0.105
Human resources Management	0.637
suppliers	0.258
Inconsistency Ratio = 0.04	