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A Group AHP-based Tool to Evaluate Effective Factors Toward Leanness in Automotive Industries

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Abstract: In dealing with global markets and international standards the organizations require the use of engineering methods of new management. Lean manufacturing is one of the management philosophies, as a systematic approach regarding to eliminating waste in the production process by using all assets of a company. The aim of study was to identify the challenges faced by the automotive industry in Iran. The next objectives are to identify and prioritize factors that would support implementation of Lean Manufacturing in the automotive industry. The methodology is based on two phases, with in Phase 1 (qualitative), ten effective factors (10 Ms) were selected. Moreover in this phase more than 50 sub-factors were identified in the research literature. In Phase 2 (quantitative), experts were asked to assign an importance value to each factor and the group AHP technique was used to prioritize the effective factors and sub-factors. The result of this study can be used for lean managers, experts and senior managers who want to implement lean in companies. It shows the main factors to leanness and to prioritize them.

Key words: Group analytic hierarchy process (GAHP), leanness, automotive industry, effective factor, 10 Ms

INTRODUCTION

Automotive industries play an important role in the overall development of countries (Mather *et al*., 2007). Automotive industries are facing the challenges of globalization; therefore, the need for an integrated approach to continuous assessment of these challenges is essential (Forouzan and Mirassadallahi, 2008). Countries that are changing after revolution, such as Iran, face additional challenges. Manufacturing firms will experience changes during this transition and factors such as: performance, technology, cost competitiveness; product quality, after-sales service and customer satisfaction will be differentiation factors in the markets (Moutabian, 2005). Consequently, in dealing with global markets and international standards, organizations require the use of new engineering methods of management. Lean Manufacturing (LM) which has evolved and is now referred to as Lean thinking, is one of these management philosophies. Management philosophies allow a business the opportunity to measure and analyze the execution of the process so that lead to continuous improvement (Owaied *et al*., 2011). It can be defined a systematic approach to eliminating waste in the production process by using all the assets of a company.

In order to identify and prioritize critical factors relating to Leanness, this study has used numerous pieces of previous research. The main resources studied in this area included: Mann (2010), Rostamzadeh and Sofian (2009, 2011), Hosseini-Amin (2009), Moutabian (2005) and Taghizadeh (2001) and others.

This research consisted of quantitative, qualitative and review methods. The aim of this research was to identify a set of 10 effective factors referred to as the 10 Ms: management, manpower, machine, material, method, money, minutes, measurement, market and ministry. These factors cover: hardware, software, human ware and organization ware. The 10 Ms were prioritized according to their levels of effectiveness on the desired condition of Leanness. A conceptual diagram of effective factors to Leanness is shown in Fig. 1.

To realize the aim of this research the following two objectives were developed:

- To identify the main effective factors and sub-factors to achieving Leanness
- To rank the factors and sub-factors

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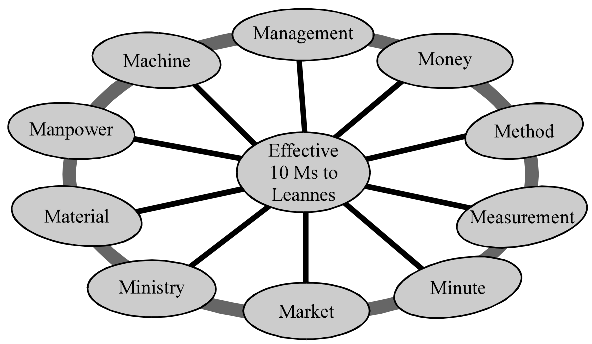

Fig. 1: A conceptual diagram of effective 10 Ms to leanness

Moreover, the following questions are addressed in this research in relation to the literature:

- What are the challenges faced by the automotive industry?
- What are the variables in identification of effective factors?

The main objective of this research is identifying and prioritizing 10 effective factors to leanness in automotive industries.

AUTOMOTIVE INDUSTRY IN IRAN

Automakers: Today, Iran's automobile industry is not only the second most active industry but also the fastest growing industry in Iran (Mather *et al*., 2007); it is growing year-by-year and has become one of Iran's key economic activities, after its oil and gas industry (Aminali, 2007). The global rank of scientific production in Iran is 40 (Mahdi and Pourgol-Mohammad, 2011); while in 2007, Iran was the 16th largest motor vehicle producer in the world (1.43%), the largest automaker in the Middle East and one of the leading frontrunners in the Asian continent (SAPCO, 2008).

Currently, there are over 25 automakers in Iran producing both light and heavy vehicles (PVRC, 2007; Mather *et al*., 2007). These automakers are in joint ventures with several popular international automakers such as Peugeot, Citroen (France), Volkswagen (Germany), Nissan (Japan), Toyota (Japan), Kia Motors (South Korea), Proton (Malaysia), Chery (China) and since 1991 with Renault (France), B.M.W, Mercedes Benz (Germany) and Daewoo and Hyundai (South Korea). (Iran's two largest automakers are Iran Khodro and Saipa. The Iranian government is keen not only to export cars but also to export factories to assemble kits of its cars (Mather *et al*., 2007).

Auto parts: Supplying Automotive Parts Co. (Sapco) and Sazeh Gostar Saipa Co. (SGSCo) are the purchasing arms of Iran Khodro and Saipa, respectively. The Iranian automotive parts industry consists of approximately 1200 companies (15000 factories) that include those affiliated to vehicle manufacturers as well as independent firms. The industry consists of two primary sectors: Original Equipment Manufacturing (OEM) suppliers which produce parts for automakers and After-Market Parts Manufacturers (AMPM) which produce replacement parts for vehicles.

Iran's auto industry began in 1959 and before the Revolution of 1979 it progressed from the assembly of imported parts to design and production of spare parts. Recently, there has been a large downfall in auto production due to a shortage of qualified engineers and the closure of car factories (Forouzan and Mirassadallahi, 2008).

The same difficulties are faced by the automotive parts industry in Iran as those faced by other industries, namely a lack of liquidity and inadequate credit facilities. The inability of the country's automotive industry to finance its projects competitively is a result of the fact that it is in private ownership. A lack of foreign investment and the weakness of the currency make the problems worse. As a result, there has been a reduction in imports of foreign technology (Nikoueghbal and Valibeigi, 2005).

CHALLENGES TO LEANNESS IN IRAN

Problems and pitfalls: Moutabian (2005) categorized obstacles to Leanness in Iran into four factors: focus on process Kaizen instead of flow Kaizen, technique issues (detechnicalization), lack of coordination in implementation and to start outside instead of inside. Forouzan and Mirassadallahi (2008) stated that the problems of Iranian automotive industries were: low quality, high price, internal demand and low world market share. Moreover, Nikoueghbal and Valibeigi (2005) explained that the biggest problems facing industry in Iran are lack of competition and marketing.

Hosseini-Amin (2009) showed that the main problems and obstacles to Leanness in Iran were various: senior management, middle management, lack of participation management. The other hindrances were mentioned: lack of Lean leadership, lack of comparative market, government policy. Furthermore, lack of team working, lack of shop floor management and resistance to change were important because they prevent Lean success. However, experts believe that high-cost Leanness, the complexity and difficulty of LM, minimum Lean learning, lack of belief, creating idle time, equipment and machines, are not the main obstacles to LM implementation (Moutabian, 2005). It seems that the most important issues affecting the implementation of Leanness in Iran are managerial, political and cultural problems, not budgeting or knowledge. Because these issues have different characteristics, different methods in model building and optimization of these problems are required (Jahan *et al*., 2010; Kazemzadeh *et al*., 2008). The complexity of production structures are based on systems theory and structure, therefore, effective production structures of an enterprise have to be designed to resolve these problems (Maksimovic *et al*., 2010).

Urgency to improvement: The biggest problem dogging industry in Iran is the lack of competition. This issue is very important because a production unit uses machinery, material and labor that create costs. The finished goods are traded in the market place to generate profit which in turn absorbs these costs. It follows, therefore, that the higher the profit margin the greater the opportunity for expansion; lack of competition hampers this progress (Nikoueghbal and Valibeigi, 2005). One of the problems facing automakers and parts makers is too much productivity in world economics and low growth of this index in Iran. Iran also has difficulty meeting environmental concerns because the quality of their products is not comparable with global standards due to the low level of technical expertise (Forouzan and Mirassadallahi, 2008).

To meet world standards and customers' multiple expectancies, traditional methods in R and D, supply and production, new products development and so on are unsuitable and inefficient (Sepehri, 2006). Therefore,, to export vehicles successfully, the Iranian automotive industry has first to identify challenges and then resolve their quality, efficiency, delivery and other issues, by using new methods of management approaches.

EFFECTIVE FACTORS TO LEANNESS

Mann (2010) categorized LM tools and techniques into two groups: visual controls (to see problems) and Kaizen tools (to solve problems). One of the tools in Mann's visual controls is 4 Ms (material, machine, man, method); Taghizadeh (2001) added 3 other Ms (management, marketing, money); Rostamzadeh and Sofian (2009) prioritized effective 7 Ms to improve production system performance.

Researchers have extended 7 to 10 M: the additional 3 Ms are measurement, minutes and ministry/government and the 10 Ms are categorized into internal and external. The internal effective 8 Ms are: management, material, machine, manpower, method, money, measurement, minutes; the external 2 Ms are: market and ministry.

If Lean culture is realized and people achieve Lean thinking, then the problems are made visible and are understood before considering the solutions. So, this study presented effective factors to Leanness based on the categories of effective factors as a Fishbone diagram (Fig. 2).

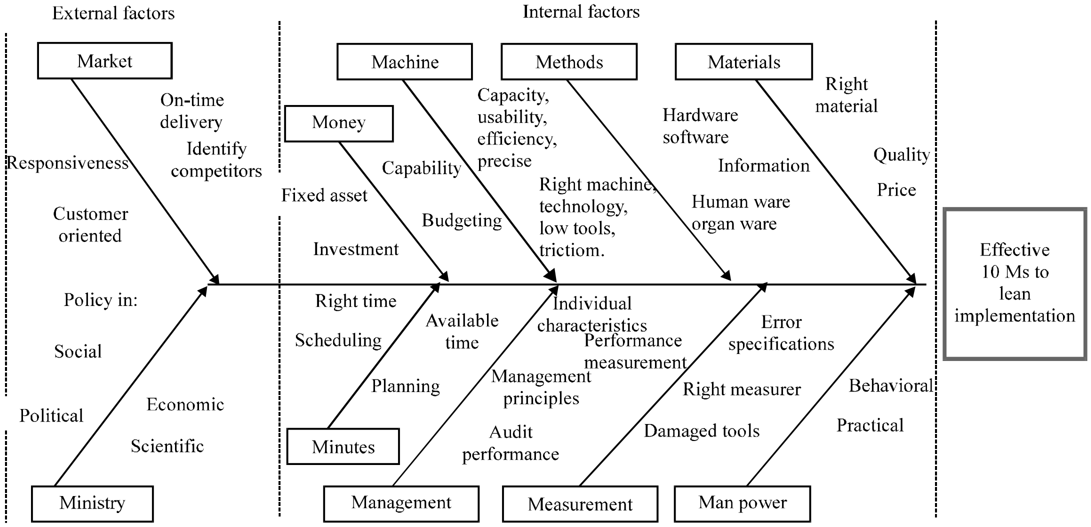

Fig. 2: Effective factors to lean implementation based on 10 Ms

ANALYTIC HIERARCHY PROCESS

The Analytic Hierarchy Process (AHP) is a theory of relative measurement with absolute scales of both tangible and intangible factors based on the judgment of experts (Ahmad, 2005). AHP is a widely used Multi-criteria Decision Making (MCDM) method introduced by Saaty (1980) and it resolves decision-making problems by structuring each problem into a hierarchy with different levels of factors. In other words, AHP structures a decision problem into a hierarchy and evaluates multi-criteria tangible and intangible factors systematically. AHP has been applied in numerous fields (Forman and Gass, 2001; Vargas, 1990), including many software selection decisions and is discussed in several books (Asgharpour, 2008; Bourke *et al*., 1993; Saaty, 1980).

The use of AHP instead of another multi-criteria technique is due to the following reasons:

- Quantitative and qualitative factors can be included in the decision making
- A large quantity of factors can be considered
- A flexible hierarchy can be constructed according to the problem

METHODOLOGY

The two phases of the research methodology were as follows (Fig. 3):

Phase 1: The first phase of this study explored and selected effective factors for automotive industries; data collection was by questionnaire. Weights of the factors were calculated by using AHP that had been prepared by experts. Consistency specification was then executed: if the consistency was more than 0.1, then the data were refined until this number decreased to equal or less than 0.1. This phase was important because it provided the knowledge platform for the next phase.

Phase 2: The applied methodology for this phase is based on the output of the previous phase and the same method was used. In this phase, the weights of sub-factors with respect to each factor were calculated. At the end of this phase, all of the effective factors and sub-factors were ranked.

Figure 4 shows a two-level hierarchy model for the automotive industries problem. The first level presents the goal of the problem which is to rank the ten factors: Management, Manpower, Machine, Material, Method, Money, Market, Ministry/government, Minutes and

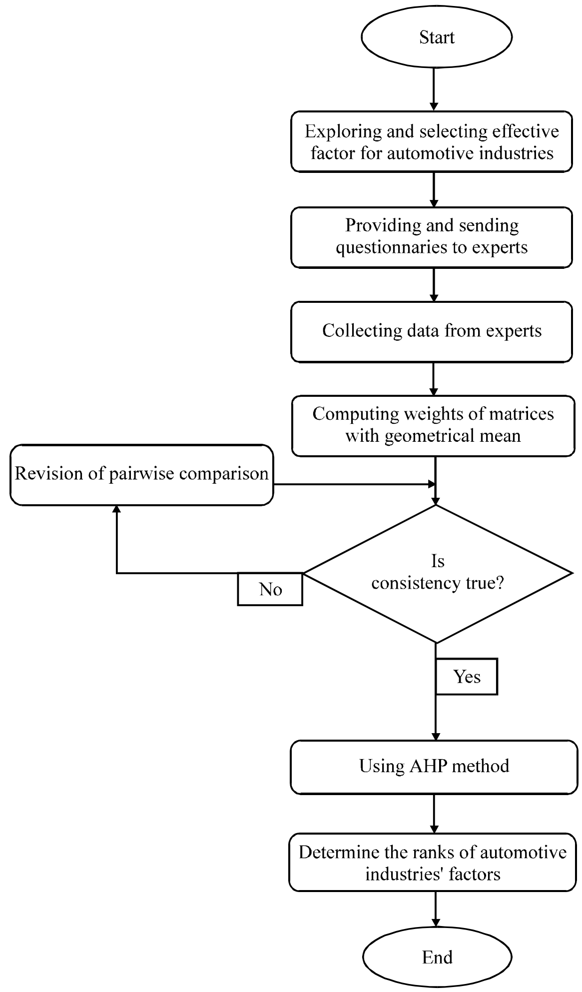

Fig. 3: Framework of research methodology

Measure. The third level consists of 51 effective sub-factors for automotive industries as follows:

- Machine (Right machine, Capacity, Usability, Efficiency, Precise, Set up time, Maintenance, Planning and control and Layout planning); Management (Management principles, Individual characteristics and Performance); Manpower (Behavior and Practical); Material (Right material, Quality, Cost, Technical characteristics, Delivery on time, Transportation, Storage, Information and Suppliers); Measurement (Management principles, Individual characteristics and Performance); Method (Hardware, Software, Human ware and Organization ware); Minutes (Available time, Right time and Scheduling); Money (Financial capabilities, Funding and allocation, Buying new technology, Fixed assets, Investment and Budgeting); Ministry (Political

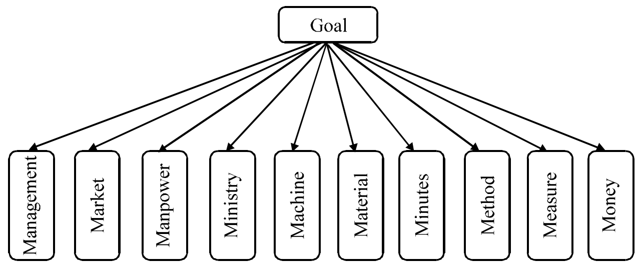

Fig. 4: Hierarchy model of research

policy, Social policy, Economic policy, Scientific policy, Available scientific resources); Market (5P, Competitors, Identify markets, Customer oriented, Responsiveness, Communication and Reputation). The factors are assumed to be independent in the hierarchy; this can be described as an independence case between factors (Saaty, 1987)

Comparison matrix: The comparison matrix is a part of the model structure of the AHP. The main difficulty is to reconcile the inevitable inconsistency of the pairwise comparison matrix elicited from the decision makers in real-world applications (Choo and Wedley, 2004). The application of expert opinion has been found in various studies covering a wide spectrum of disciplines (Goossens *et al*., 2008). Decision maker (Expert) is a skillful person who has extensive training and knowledge on the specific area. Skillful opinion can be well-defined as the expert's formal judgment on the matter in which the expert's opinion is required (Hussin and Hashim, 2011; Ayub, 2001).

The steps of preparing the comparison matrix can be generally listed as follows:

Step 1: To define the problem and specify the research objective

Step 2: To construct a squared pairwise comparison matrix ($n \times n$) for factors with respect to objective by using Saaty's 1-9 scale of pairwise comparisons shown in Table 1

The pairwise comparisons are done in terms of which element dominates the other.

Step 3: There are:

$$\frac{n \times (n-1)}{2}$$

Judgments required to develop the set of matrix in Step 2. Reciprocals are automatically assigned in each pairwise comparison.

Table 1: Saaty's-19 Scale of pairwise comparisons

Intensity of importance	Definition
1	Equal Importance
2	Weak or Slight
3	Moderate Importance
4	Moderate Plus
5	Strong Importance
6	Strong Plus
7	Very Strong
8	Very, very Strong
9	Extreme Importance

Step 4: Synthesizing the pairwise comparison matrix is performed by dividing each element of the matrix by its column total

Step 5: The priority vector can be obtained by finding the row averages

Step 6: The weighted sum matrix is found by multiplying the pairwise comparison matrix and priority vector

Step 7: All the elements of the weighted sum matrix are divided by their respective priority vector element

Step 8: Compute the average of this value to obtain λ_{max}

Step 9: Find the Consistency Index (CI) as follows:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (1)$$

where, n is the matrix size.

Step 10: Calculate the Consistency Ratio (CR) as follows:

$$CR = \frac{CI}{RI} \quad (2)$$

Judgment consistency can be checked by taking the CR of CI with the appropriate value in Table 2. The CR is acceptable if it does not exceed 0.10.

If it does exceed 0.10, then the judgment matrix is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved.

Fortunately, there is no need to implement the steps manually. Professional commercial software, such as

Super Decisions and Expert Choice software are available on the market to simplify the implementation of these steps and automate many of its computations.

Procedure of group AHP:

Step 1: Structure the decision problem
Structure the hierarchy from the top (goal) through the intermediate levels (factors) and the lowest level (sub-factors)

Step 2: Create pairwise comparison matrix
After constructing AHP model, the priorities should be computed. Weights are assigned to each factor and sub-factor. These weights are assigned through a process of pairwise comparison. In pairwise comparison, each objective is compared at a peer level in terms of importance. At this time, a set of pairwise comparison matrices (size n×n) for each of the lower levels with one matrix for each element in the level immediately above by using the relative scale measurement shown in Table 1 was constructed. The pairwise comparisons were done in terms of which element dominates the other. In GAHP, the weights of each factor for each expert should be computed in geometrical mean and the result of this step will be used in the next step

Step 3: Determining normalized weights
By using each pairwise comparison matrix, the weight of each row was computed by matrix of "W"

$$C_{ij} = \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \quad i=1,2,\ldots n;\ j=1,2,\ldots m \tag{3}$$

$$W_i = \frac{\sum_{j=1}^{m} C_{ij}}{n} \quad i=1,2,\ldots n \text{ (denominator must be size of matrix)} \tag{4}$$

Step 4: Determine weights of sub-factors in respect to their factors

The final step is to synthesize the solution for the decision problem in order to obtain the set of priorities for alternatives. After computing the weight of factors in respect to goal, weight of sub-factors will be determined in respect to factors. They are aggregated to produce composite weights that are used to rank factors and sub-factors.

Implementation of group AHP: Six experts were asked to weight and rank factors and sub-factors and to select the most important factor for automotive industries; the collected data are presented in Table 3.

Table 3 reflects the opinion of six experts in automotive industries. Each expert applied Saaty's 1-9 scales and then the geometrical mean and rounding off were computed. For example in column 5 and row 3, the value of 2.18 (≅2) indicates that Manpower is weak or of lesser importance than Measurement; the CR of 0.028 (i.e., less than 0.1) indicates that there is sufficient consistency.

Table 4 illustrates CR of factors and Table 5 and 6 demonstrates sub-factors with respect to goal and factors, respectively.

An additional ten tables were computed in which the sub-factors were compared with each factor; Table 5 and 6 are examples.

Table 2: Average random consistency (RI)

Size of matrix	Random consistency
1	0
2	0
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10 and more	1.49

Table 3: Comparing factors with respect to goal

	Machine	Management	Manpower	Material	Measurement	Method	Minutes	Money	Ministry	Market
Machine	1.00	0.18	0.71	0.76	2.24	0.69	0.69	1.51	0.64	0.26
Management	5.50	1.00	2.49	2.41	3.24	3.52	2.52	1.80	2.33	1.57
Manpower	1.41	0.40	1.00	2.22	2.18	1.41	1.70	1.18	1.20	0.43
Material	1.31	0.41	0.45	1.00	2.18	1.16	1.44	1.22	0.79	0.53
Measurement	0.45	0.31	0.46	0.46	1.00	0.44	0.89	0.76	0.86	0.56
Method	1.46	0.28	0.71	0.86	2.28	1.00	1.62	1.83	1.26	0.83
Minutes	1.44	0.40	0.59	0.69	1.12	0.62	1.00	1.02	0.85	0.63
Money	0.66	0.55	0.84	0.82	1.32	0.55	0.98	1.00	0.69	0.38
Ministry	1.57	0.43	0.83	1.26	1.16	0.79	1.18	1.44	1.00	0.66
Market	3.88	0.64	2.33	1.89	1.78	1.20	1.60	2.64	1.51	1.00

Table 4: List of consistency ratios

Comparing factors or sub-factors	
With respect to	Consistency ratio
Goal	0.028
Management	0.002
Manpower	0
Machine	0.023
Material	0.029
Method	0.005
Money	0.016
Market	0.013
Mammon	0.039
Minute	0.002
Measure	0

Table 5: Comparing sub-factors with respect to management

	Management principles	Individual characteristics	Performance
Management principles	1.00	1.55	2.09
Individual characteristics	0.64	1.00	1.16
Performance	0.48	0.86	1.00

The Table 6 has been completed by five expert's point of view. In this Table, 9 sub-criteria have compared by themselves with respect to their criteria. The result of this Table is shown the weights of theses sub-criteria.

In Table 7, the weights of factors and sub-factors have been shown separately. In addition to weights of criteria, the weights of sub-factors that it is called "local weight" have been specified. Therefore, sum of local weights of sub-factors will be 1.

These ten factors contain the geometrical mean of the experts' data. The CR of these ten factors was gathered in Table 4 and as shown, they were less than 0.1 therefore, they show sufficient consistency. It has been illustrated the weights of factors using a Bar chart (Fig. 5).

In Table 7, the weights of factors and sub-factors have been shown separately.

Table 6: Comparing sub-factors with respect to machine

	Right machine	Capacity	Usability	Efficiency	Precise	Set up time	Maintenance	Planning and control	Layout planning
Right machine	1.00	2.49	1.28	1.10	1.12	1.73	1.26	0.89	1.26
Capacity	0.40	1.00	1.32	0.87	1.20	1.32	1.00	0.69	0.89
Usability	0.78	0.75	1.00	1.07	2.22	1.59	1.59	1.05	1.70
Efficiency	0.91	1.15	0.93	1.00	1.55	1.82	1.35	1.12	1.86
Precise	0.89	0.83	0.45	0.64	1.00	1.16	0.79	1.00	1.20
Set up time	0.58	0.76	0.63	0.55	0.86	1.00	0.66	0.83	1.12
Maintenance	0.79	1.00	0.63	0.74	1.26	1.51	1.00	1.94	2.29
Planning and control	1.12	1.44	0.95	0.89	1.00	1.20	0.51	1.00	1.76
Layout planning	0.79	1.12	0.59	0.54	0.83	0.89	0.44	0.57	1.00

Table 7: The weights of factors and sub-factors have been shown separately

No.	Factors and sub-factors	Weights	No.	Factors and sub-factors	Weights
1.0	Machine	0.066	6.0	Method	0.097
1.1	Right machine	0.141	6.1	Hardware	0.229
1.2	Capacity	0.102	6.2	Software	0.199
1.3	Usability	0.135	6.3	Human ware	0.290
1.4	Efficiency	0.133	6.4	Organization ware	0.281
1.5	Precise	0.092	7.0	Minutes	0.070
1.6	Set up time	0.080	7.1	Available time	0.244
1.7	Maintenance	0.125	7.2	Right time	0.390
1.8	Planning and control	0.114	7.3	Scheduling	0.366
1.9	Layout planning	0.078	8.0	Money	0.068
2.0	Management	0.218	8.1	Financial capabilities	0.216
2.1	Management Principles	0.473	8.2	Funding and allocation	0.235
2.2	Individual characteristics	0.290	8.3	Buying new technology	0.154
2.3	Performance	0.237	8.4	Fixed assets	0.118
3.0	Manpower	0.106	8.5	Investment	0.143
3.1	Behavioral	0.616	8.6	Budgeting	0.134
3.2	Practical	0.384	9.0	Ministry/government	0.086
4.0	Material	0.084	9.1	Political policy	0.206
4.1	Right material	0.180	9.2	Social policy	0.182
4.2	Quality	0.131	9.3	Economic policy	0.243
4.3	Cost	0.156	9.4	Scientific policy	0.203
4.4	Technical characteristics	0.111	9.5	Available scientific resources	0.166
4.5	Delivery on time	0.112	10.0	Market	0.151
4.6	Transportation	0.067	10.1	5P	0.180
4.7	Storage	0.062	10.2	Competitors	0.213
4.8	Information	0.092	10.3	Identify markets	0.161
4.9	Suppliers	0.089	10.4	Customer oriented	0.185
5.0	Measurement	0.054	10.5	Responsiveness	0.168
5.1	Performance measurement	0.38	10.6	Communication	0.158
5.2	Error specification	0.32	10.7	Reputation	0.115
5.3	Right measurer	0.30			

Table 8: Ranked factors in respect to goal

10 Ms	Score
Management	0.218
Market	0.151
Manpower	0.106
Method	0.097
Ministry	0.086
Material	0.084
Minutes	0.070
Money	0.068
Machine	0.066
Measurement	0.054

Table 9: Comparison between results of different researches

Rostamzadeh and Sofian (2009)	Rostamzadeh and Sofian (2011)	Present research
Management	Management	Management
Money	Money	Market
Manpower	Manpower	Manpower
Market	Market	Method
Machine	Method	Ministry
Material	Material	Material
Method	Machine	Minutes
		Money
		Machine
		Measurement

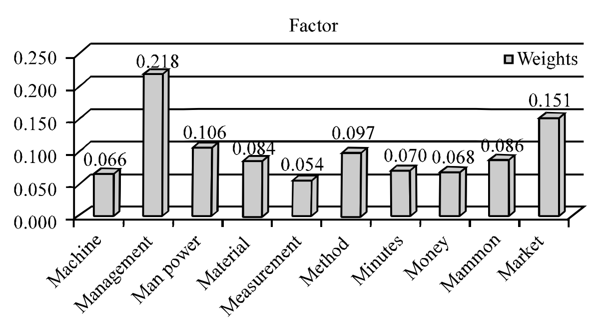

Fig. 5: Weights of factors with respect oto goal

As a result, the factors in order of importance are: Management, Market, Manpower, Method, Ministry, Material, Minutes, Money, Machine and Measurement (Table 8).

Moreover according to a comparative study of the results of different researches on effective factors to leanness is shown in Table 9. As it is seen in this Table 9, the results are very similar. Hence, this study supported the other researches such as, Rostamzadeh and Sofian (2009, 2011), Hosseini-Amin (2009), Taghizadeh (2001). Of course there is a basic difference between the results. Rostamzadeh and Sofian (2009) showed money is very important but the result of in this research shows money is not important. Because based on conditions of Iran after revolution, critical factors are unlike to money.

DISCUSSION

This study investigated methodologies for selecting effective factors to leanness, factors evaluation, sub-factors evaluation that support decision makers in evaluating effective factors.

In fact this study explored the importance of selected 10 Ms to LM implementation in the Iranian automotive industry.

The main value of the study was that it identified:

- The challenges faced by the automotive industry in Iran (section 3)
- Effective factors and sub-factors of LM implementation in the automotive industry based on the research literature (section 4)
- The most important factors and sub-factors based on prioritization by experts (section 7)

Firstly, it was found that the three most important challenges to Leanness facing manufacturers were: technical, managerial and environmental.

Secondly, more than 50 sub-factors were categorized under 10 main factors (10 Ms): Management, Market, Manpower, Method, Ministry/government, Material, Minutes, Money, Machine and Measurement.

Thirdly, analyses and prioritization of the effective factors to Lean success showed that respondents stressed the following sub-factors:

- Management Principles, Individual characteristics and Performance of management
- Behavioral and practical manpower
- Available time, Right time, Scheduling (related to minutes)
- Economic policy, political policy, social policy, available scientific resources (related to Ministry/government)

This shows that task-orientation, individual characteristics (commitment and proficiency) and performance assessment of managers were very important. Then, of next importance was the evaluation of behavioral and practical aspects of manpower; then time condition and finally, government support.

So, this study not only supported the other researches Rostamzadeh and Sofian (2009, 2011), Hosseini-Amin (2009) and Taghizadeh (2001) but also developed their working.

CONCLUSION

In this study, pair-wise comparison of 10 Ms has been carried out independently in six groups using the AHP model. Taking into account the meaning and concept of each 10 Ms, the highest degree of importance has been allocated to management (0.218-internal factor).

The next highest level is given to market (0.151-external factor) and others factors were also scored.

Moreover, a survey of the sub-factors shows that the highest degree of importance is allocated to behavioral and practical issues (sub-factors of manpower) and management principles (sub-factor of management).

This study has been focused on a manufacturing plant. However, the results can also be used for other types of companies that are located in a competitive environment and would like to gain a high level of competitive advantage.

RECOMMENDATION

In this study, by using the GAHP approach was ranked effective factors for Leanness in Iranian automotive industries. The limitation of this study is that AHP ignores the fuzziness of executives' judgment during the decision-making process. However, fuzzy numbers can be used to obtain the evaluation matrix and it is suggested that the Fuzzy GAHP method be used in future research.

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