

A FIELD STUDY ON MEASURING THE LEAN MATURITY LEVEL IN MANUFACTURING FIRMS IN TURKEY

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ÖZET

Temelleri Toyota Üretim Sistemi'ne dayanan *Yalın Düşünce*, israfların yok edilerek sistemlerin performanslarının iyileştirilmesini gösteren 17 adet orta ve büyük ölçekli kuruluşun fabrikalarının bu tekniklerdeki olgunluk düzeyleri gözlemlenmiş ve hazırlanan bölümden oluşmaktadır. Birinci bölüm Üretim Yönetimi'nde uygulanan teknikler, ikinci bölüm ise Stratejik Yönetim konularını içerir. Sorular ve yanıtlar ve gözlemlere dayanılarak her bir teknik için fabrikaya 1 ile 5 arasında bir puan verilmiştir. Her bileşen için belirlenen teknikteki olgunluk düzeyleri tespit edilmiştir. Bu kuruluşların zayıf ve güçlü yönlerinin görsel olarak algılanmasını kolaylaştıran bölümlerinde incelenen konuları kapsayacak şekilde radar diyagramları çizilmiştir.

ABSTRACT

Lean Thinking, which is based on Toyota Production System, is focused on performance improvements in many areas by the elimination of waste. In this study, the maturity levels of 17 medium and large-scale companies were examined so as to measure the maturity level of each factory in Lean Production Techniques. A survey has been applied to the executive people of the company. The survey has two sections. The first section is concerned with Production Management, and the second section is about Strategic Management. According to the answers, which were given to the questions of each technique a score between 1 and 5, was given to the factory for each technique. The maturity level in each technique was determined by using radar diagrams. Radar diagrams were drawn in order to simplify the perception of the strengths and the weaknesses of the examined companies in each technique.

INTRODUCTION

Lean Production is an approach, which was originated with Taiichi Ohno in Toyota Motor Company, was called Toyota Production System in the past. The basis of this system is the elimination of all non value-added operations, materials, and labor in order to increase the performance of the system [1].

In 1990, the book called *The Machine that Changed the World* that was written by Womack and Jones provided the dissemination of the concept of Lean Production. The main purpose of the publication of this book was to warn the traditional mass production companies about the new production and management approach, which was pioneered by Toyota Motor Company [2]. In 1996, the book named *Lean Thinking* [3] was published in order to both summarize the concepts of Lean Production and establish a guide for the firms, which are trying to become *lean*.

Baudin [4] defined Lean Production as the pursuit of concurrent improvement in all measures of manufacturing performance by the elimination of waste through projects that change the physical organization of work on the shop floor, logistics and production control throughout the supply chain, and the way human effort is applied in both production and supply tasks. It must be noted that Baudin defines Lean Production as a pursuit, which is characterized with continuous improvement efforts, rather than as an approach [4].

The purpose of this research is to measure the extent to which the Lean Production techniques are applied by using both a questionnaire that was previously prepared and the observations received on the shop floor; to compare the maturity level of the companies analyzed with the level of other production firms in the world and proposing the future action plans that must be followed by the analyzed companies in Turkey.

The past researches, which are concerned with Lean Production/ Just-in-Time (JIT) Production, are intended to be classified, critical JIT implementation elements are tried to be identified and classified and a group of critical elements are established by Ramarapu, Mehra and Frolick [5]. As a result of this research all JIT implementation articles are grouped into 3 groups, which are conceptual studies, empirical studies and simulation and/or mathematical models. Ramarapu et al. [5] concluded that reduction in waste, reduced set-up times, continuous quality improvement, cross-training/education, reliable and prompt deliveries are the most critical elements in JIT implementation. These elements were determined by evaluating the frequency of citation in the literature. Oliver et al. [6] intended to analyze the performance of European Auto components Industry in terms of quality and productivity, investigated the relationship between the Lean Manufacturing practices and manufacturing performance and searched the dissemination of Lean Production principles across Europe [6]. A questionnaire was used as a measurement tool. Although the study covered 9 Japanese, 18 American and 44 European plants, European and Japanese firms were compared in detail. Japanese firms were found to be the most successful in terms of all the manufacturing practices. European plants lagged both Japanese and American plants. However variations in the performances of different European countries were determined. French plants had the highest performance level in manufacturing practices of all the European plants that are included in the study. Panizzolo [7] investigated 27 manufacturers in order to examine how lean production model was applied, to recognize the areas characterized by major problems, to identify the critical factors in implementation and to highlight the implications both for the firm and for its relationships with suppliers and customers. The degree of adoption of various adoption programs in six areas was examined by using a questionnaire, which has been answered by the researchers and the company executives during an interview. The examined areas are process and equipment, manufacturing planning and control, human resources, product design, supplier relationships and customer relationships. The responses about the projects were evaluated by determining the percentage of the companies that adapted to a limited extent or fully adapted to these projects. Moreover Sohal and Egglestone [8] investigated the extent of Lean Production implementation within the Australian organizations, the structural changes taking place as a result of the implementation of Lean Production principles and identify the benefits of and future trends in Lean Production. Responses, which were given to the survey of this study, showed that Quality Management, JIT and Kaizen were the most widespread Lean Production techniques. In addition increase in quality levels; process/ production improvement, customer satisfaction and inventory control were the most frequently expressed benefits from introduction of Lean Production.

Lean maturity level is the measure of current of practices in several components of lean, each assessed according to well-defined criteria.

Although there are many research articles about JIT / Lean Production, the limited researches about the lean implementations are available.

FIELD ANALYSIS ON MEASURING THE LEAN MATURITY LEVEL IN MANUFACTURING FIRMS IN TURKEY

We performed the field study for measuring the lean maturity level in 17 large-scale manufacturing firms in Turkey. Before the discussions on the questionnaire, the authors observed the shop floor and mutual effort was spent in order to answer the questionnaire accurately.

The questionnaire used in the analysis consisted of three kinds of questions:

1. Questions, which ask for selecting the choice, which reflects the current situation most accurately.
2. Questions with the choices of Yes/No.
3. Questions, which ask for explanation of the implementations of the techniques with a few sentences.

The choices of first kind of questions are in 1-5 scale and each choice indicates the level of implementation.

The survey has two sections. The first section is about Production Management and the second one is about Strategic Management. The examined issues in each section are listed on Table 1.

The mean values for each component is calculated in the following way: for example a firm, which was observed to be in the third level was given score of "3". In addition the mean value of scores of all companies is calculated for each component that is examined in this study.

This model has been formed depending on both the components that were frequently mentioned in the literature and the past experiences in industry.

17 firms are involved in our research. As it was not the purpose of this study to focus on a specific industry, the firms that are involved in the research are from different industries. Each of Auto components, defense and electrical industries has 18 % share in the research and constitute more than half of the sample. Agricultural vehicles, metal processing and durable goods industries have equal share, which is 12 % in the sample as shown in Figure 1.

The results in strategic management, in other words characteristics that represent the agility of the firms, were not covered in this study but these will be explained in another paper.

Production Management

Respondents were asked the Lean Production techniques that have been applied. Eighteen choices were given. Visual control was chosen by thirteen respondents and is determined to be the most frequently used technique.

All of the companies are conscious about and trying to eliminate wastes. Industrial Housekeeping (5S), Standard Processes, Problem Solving Techniques (Fishbone, Brainstorming etc.) take the second rank in usage frequency. Supplier improvement and Pull/ Hybrid production control systems are the least frequently applied techniques, which were chosen by 6 respondents. Number of applicants of each Lean Production technique is presented in Figure 2.

Table 1. The examined issues in the Survey

Production Management	Strategic Management
Elimination of Wastes	Teamwork
Pull / Hybrid Production Control Systems	Perfecting Core Competencies & Benchmarking
Production Planning & Scheduling	Information Systems

Setup Reduction	Timekeeping
Industrial Housekeeping (5S)	Quality Assurance
Reduction of Work-in-Process (WIP) and Inventory	Performance Measurement
Error Proof Mechanisms (Poka Yoke)	Development of New Products and Services
Visual Controls	Leveraging Knowledge and People
Cellular Manufacturing	Flexibility
Flexible Workers	Ability to Change
Total Productive Maintenance	Management Commitment in Lean Production
Supplier Relations Management	

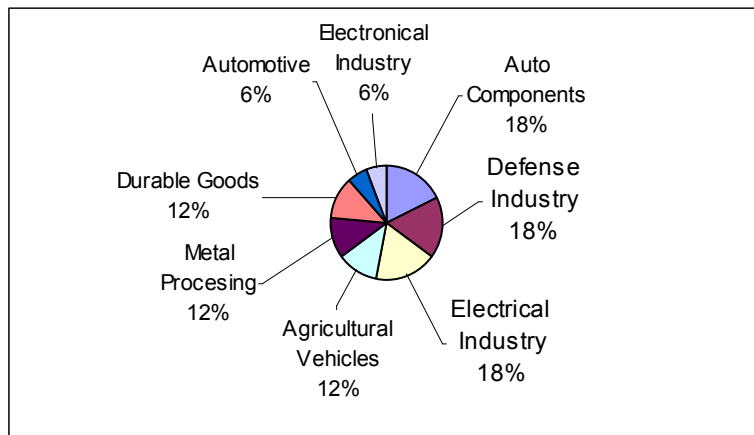
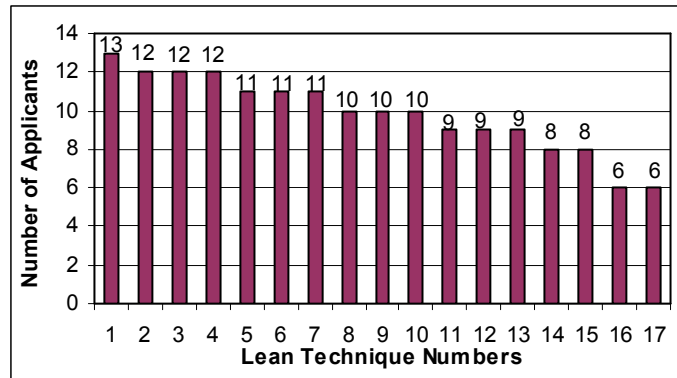


Figure 1. Firms Classified by Industry

Although these techniques have been applied, some companies are currently in the initial stages of the techniques or have slowed down or given up their studies. Lean Maturity Level of companies will be explained further in this paper. Respondents were asked how long they had been applying Lean Production techniques. The results are shown in Figure 3. The examined factories have been applying these techniques for almost five years. 59 % of the companies (ten companies) have been applying these techniques for more than five years, which represent the highest level for Lean Production implementation status. However minimum time period that these techniques are applied is one - two years by 18 % of the companies.



1. Visual Controls, 2. Industrial Housekeeping, 3. Standard Work Procedures, 4. Problem Solving Techniques, 5. Flexible Workers, 6. Problem Solving Teams, 7. Teamwork, 8. Cellular Manufacturing, 9. Setup Reduction, 10. Continuous Improvement (Kaizen) Studies, 11. Poka Yoke, 12. Total Productive Maintenance, 13. Small-lot Production, 14. Reduction of WIP, 15. Reducing the Number of Suppliers, 16. Production Control Systems, 17. Supplier Development.

Figure 2. Number of Applicants of Lean Production Techniques

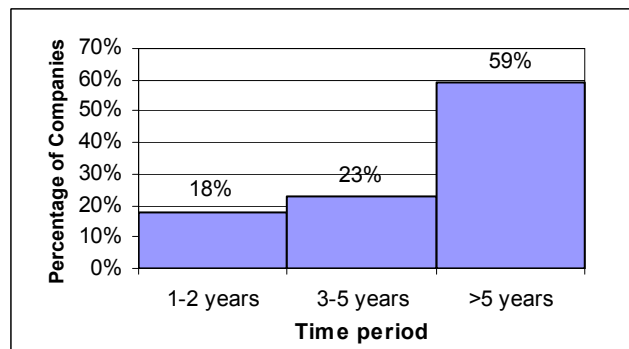


Figure 3. Lean Production Application Period

The current situation of the factories in Elimination of Waste was investigated. 71 % of the companies have adopted or fully adopted waste elimination that the percentage of wastes in total work has decreased 50 % or less of its previous level (4th and 5th Levels in 1-5 Scale). However 12 % of the factories are in 2nd level, which represents the trainings about waste elimination but no action yet. We conclude that examined factories are conscious and most of them have been activating in order to eliminate waste. However there is a lot of work to eliminate waste.

Respondents were asked the frequency of occurring of wastes in their production. Production over the demand of end user is occasionally performed. 38 % of respondents assert that transportation wastes occur in the medium level. Especially one of the firms suffers from transportation wastes. The rest of the firms claim that this waste is so low that it does not affect them negatively. 93 % of the companies declared that they prevent waste of defected products significantly. However according to the responses that were given to some of the next questions, defective product rates are between 101 and 1000 ppm. Therefore we conclude that these companies have not achieved

the level they claim. Since the observations during field analysis differ from the responses to the questionnaire, we conclude that the answers to this question are biased.

A question that searches if factories use Kanban Production Control System was asked. 35 % of the factories replied positively. This result proves that Pull/ Hybrid Production Control Systems are not wide spread in these factories. However the companies, which were examined by Panizzolo [7] in Italy expressed that 92.5 % of the companies applied Pull Production Control System. This implies the significant difference between the examined companies in Turkey and Italy in implementation of Pull / Hybrid Production Control Systems. During the interviews, executives of these companies expressed their anxiety for difficulties in application of this system. The reason of this situation can be inadequate knowledge about different implementations in the system and benefits of Kanban.

Proportion of products that are produced by using Kanban Production System was asked. The mean of the responses was 2 over 5, which means that only 11-25 % of total products is produced by using Kanban or Pull Production System. Consequently the examined factories in Turkey should implement Pull or Hybrid Production Control Systems if they would like to achieve just-in-time deliveries by holding less stock.

Types of Kanban System, which have been applied, are investigated. Only 6 firms apply Kanban System. One-card, two-cards, Standard containers and Signal Kanban are used. However the authors did not determine the CONWIP System. If the examined companies are introduced the CONWIP System, more companies will prefer this kind of Kanban System.

The respondents, who replied that they do not implement Kanban Production Control System were asked if any attempt was made and the reason of interruption in the implementation of Kanban System. Two companies replied that unpredictable market conditions caused interruption of Kanban Production Control System. The other considered that the system was useless for the factory.

The percentage of companies, which provide just-in-time deliveries, is 82 %. Some delays occur in the deliveries of the rest of the companies. However there is an economical stagnation in Turkey. Therefore authors think that when the demand increases, this percentage will probably decrease.

The respondents were asked a question about Production Planning & Scheduling. The mean value of the responses is 3.88 over 5, which implies that workers are assigned to cells/ lines daily and the scheduling system is simple and the number of late deliveries decreased. Pull Production Control System does not need a sophisticated scheduling system. This accepted reality is parallel to the questionnaire outcomes. 65 % of the examined companies use special scheduling software, which are used according to Push Production Control System. The authors observed that companies hold excessive parts/ material inventories in order to provide just-in-time deliveries. However the companies should modify their planning and scheduling system so as to respond quickly to the customer by holding as low inventory as possible.

The respondents of the questionnaire were asked about their current situation for Reduction of Setup Time. The mean value of answers to this question is 3.5 in a wide range. This means that Kaizen studies started for setup reduction, internal setups started to be converted to external and the setup times of some machines are reduced about ten minutes. We determined that 53% of the companies simplified setup work and reached SMED. Depending on the conclusions of Durmusoglu et al. [11], nearly 60 % of the companies, which are also included in this study, produce only a few products in each cell. This makes SMED approach to be applied more easily. However the product flexibility of these cells is low. Providing the SMED approach while increasing the product flexibility must be the purpose in Cellular Manufacturing.

Another question searched for the current Industrial House-keeping (5S) conditions of the companies. 71 % of the companies replied that they adopted or fully adopted 5S in their manufacturing area. In other words, they have performed the classification of necessary and unnecessary parts and tools, elimination of unnecessary ones, arrangement of things for ease of use and performed the maintenance of tidiness and cleanliness [9]. However according to the

study that was made in Italy on Lean Manufacturers [7], this percentage was 92.5 %, which was more progressive than the examined companies in Turkey.

The maturity level of companies on Reduction of Work in Process (WIP) is investigated. 71 % of the companies have reduced WIP to less than half of the level or more before the Lean studies were started. The rest of the companies should intend to decrease WIP by simplifying workflow and by using Pull / Hybrid Production Control System.

The respondents were asked finished goods inventory level and 13 companies responded. The mean value of the responses is 6.35 days with a high standard deviation of 11.56 days. Therefore the inventory levels vary significantly among the companies. For example two of the respondents have 30 days of finished goods inventory. Three auto component producer companies' response for this question is 19 hours. If we refer to the study of Oliver et al. on European Auto-components Industry [6], the lowest finished goods inventory, which is 10.7 hours, was held by Japanese companies. We conclude that auto component producers in Turkey hold more finished goods inventory than their Japanese competitors and they should improve their current inventory reduction studies. In addition we conclude that industries rather than auto components industry in Turkey increase the average value of finished goods inventory, which is an important parameter that implies the leanness of the manufacturing system.

The percentages of parts / materials, which are purchased from domestic suppliers and overseas suppliers are investigated. The average value of this variable for overseas suppliers is 59 % and the rest is for domestic suppliers. In addition percentages of payments to the domestic and to foreign suppliers on total payments were investigated. The average value for overseas suppliers is 69 %. We conclude that the examined manufacturing firms are highly dependent on suppliers' parts / materials. Although 59 % of parts / materials are provided from overseas suppliers, 69 % of total payments is allocated for them. This result supports the findings of Satir [10], who concluded that our industry was dependent on overseas suppliers

Despite high quality of foreign parts / materials, domestic parts / material suppliers cannot be able to develop their system because the main industries continue purchasing parts / products from overseas suppliers.

Average percentage of late incoming deliveries was asked to the companies. About 8% of all deliveries from suppliers are found to be late. Only 5 % of incoming deliveries of only the examined auto components producers are late. If this auto component companies in Turkey are compared with those that were considered in the study on European Auto-components Industry [6], these companies in Turkey have less percentage of late incoming deliveries than the companies in both United Kingdom and Italy. However these companies in Turkey lagged their Japanese competitors, since Japanese auto components producers receive 2.6 % of its incoming deliveries lately. In other words suppliers of auto components industry should improve their delivery performance in order to become a world-class supplier.

Defect rates for outgoing parts / products was asked to the companies in terms of parts per million (ppm). The mean value of the responses of auto component manufacturers in Turkey is about 400 ppm. This ppm level was less than the European Auto component companies' ppm level which was about 800 ppm however higher than the Japanese companies' ppm level which was about 200 ppm [6].

The companies were asked their current situation in Error-Proofing Tools (Poka Yoke). The mean value of the responses implies that Poka Yoke mechanisms have been implemented in various processes. Defected parts are not allowed to pass to the next operation. 65 % of the companies adopted or fully adopted Poka Yoke tools. This percentage of companies in Turkey is lower than that of the companies, which were examined by Panizzolo [7]. 18 % of all companies (3 companies) declared that Poka Yoke mechanisms are applied only in critical operations and not widespread. 2 firms expressed that they use only a few or no Poka Yoke devices. It is obvious that if Poka Yoke implementations are disseminated, lower defected products in ppm will be achieved.

The use of Visual Controls was investigated. The companies' responses implied that visual boards were updated and some visual tools warned the workers if any problem has occurred. 65 % of them (11 companies) declared that visual controls were adopted or totally adopted in their manufacturing environment. This percentage was also lower than that of the companies in Italy [7]. However 12 % of the companies (2 companies) expressed that they had only a few or no visual controls. The rest implied that visual controls have started to become widespread.

We concluded that importance of visual controls has not been realized well. There was a need to improve the implementations of visual controls for the examined companies.

A question about the implementations of Cellular Manufacturing (CM) was asked. Responses imply that a number of cells have been established. However cellular manufacturing has not become widespread yet. 3 companies declared that they located some machines according to product families. However no cellular layout has been established.

Cell penetration level was asked to the companies. 30 % of all manufacturing systems are found to be cellular. However in the field analysis about CM in Turkey [11] in which 60 % of the examined companies are in common with this study, cell penetration level was determined as nearly 50 %. Since this study included some companies, which did not apply CM cell penetration level was found to be lower than that of the companies for CM research.

Worker flexibility was investigated. 47 % of the companies claimed that all of their workers were able to control all types of machines within the cells. 35 % of the companies expressed that their workers were able to control more than one machine. The rest implied that cross-trainings have been continued however the worker flexibility has not achieved the satisfactory level. We infer that worker flexibility is one of the aspects of Lean Production that have to be improved in Turkey.

Implementations on Total Productive Maintenance (TPM) were investigated. Responses that were given imply that TPM Program was established. But interruptions occurred while applying these programs. 47 % of the companies replied that TPM was adopted or fully adopted. This percentage indicates the inadequate TPM implementations in Turkey.

The percentage of time for machine stoppages due to machine breakdowns was asked to the respondents. The mean value was between 2 % and 5 %. In addition 5 companies implied that percentage of time for machine stoppages was less than 2 %.

The maturity level in Lean Production Techniques of the examined companies is shown in Figure 4.

Strategic Management

The maturity level of the companies in Perfecting Core Competencies & Benchmarking was examined. 53% of the companies have already determined the strengths and weaknesses of themselves and of their competitor. 23.5% of the firms have been superior to most of their competitor and the employees of these companies have been working in order to create value and make innovations for the customers. Only 11.8% of 17 companies are in the fifth and the highest maturity level, which means that these firms are in leader position in their industrial sector. The rest of the firms either do nothing for perfecting their core competencies or making research on these issues but have not made any implementation yet.

The percentage of the firms, which had organized and have been executing their jobs by teams, is 53%. In other words their organization structure have been arranged according to specific product families or markets.

In addition, 94% of 17 companies have been using teams in order to solve the quality problems, make innovations in the products or processes.

Although the companies seemed to be extremely mature in Quality Assurance, the results for this issue and the ones for (Poka Yoke) contradict to each other since 65% of all the firms are adopting

or fully adopting Error Proof Mechanisms. However 88% of the companies claimed that they are competent in quality assurance of their products & processes, implementing teamwork to solve quality problems continuously, each employee is responsible for the quality of his product and zero fault philosophy had been totally assimilated by every employee of the firm. However it is clear that the examined companies do not have such competent implementations in quality assurance in production. Therefore the results for Quality Assurance are biased.

Most of firms (64.7%) is in fourth maturity level, which represents that an integrated information system that covers the whole departments of the firm exists, the database/databases have been present and are updated continuously and all modules of the information system could function properly (internal integration) and meet the all requirements. 17.6% of the firms were able to adopt external integration of the information system to some customers, suppliers, which means that they had reached the fifth maturity level. The examples for the implementations of these firms are Electronic Data Transfer among the company and the suppliers, international electronic mail web among the main company and its dealers. The firms, which have been in the third level, were not able to provide internal integration totally and all the information requirements could not be provided. The percentage of these firms is 11.8%. The rest of the firms are at the first or at the second maturity level and have many things to do in order to improve themselves in that issue.

Product Development is another important issue of Strategic Management of the companies. 41.2% of all companies involve the employees from different departments and the suppliers in product development projects. Flexible products and services are designed in these studies. These firms are in the third level. The firms that are in fourth level were able to integrate their design system into the production planning system, which provided quick response to the customer in production of desired products. The firms in this level denote only 5.9% of all examined companies. The companies that are in the fifth level denote 17.6% of all examined firms and they were able to extremely shorten the design and production time. 23.5% of all firms are in the second level, which means that they design or improve their products by using teams that are formed by the employees from Research and Development, Manufacturing and Marketing Departments but suppliers are not involved in these projects. The rest is the first level, which means that these firms improve or design products without any feedback from the customers or suppliers. Only Research and Development Department works in this issue. Current problems of the examined Turkish companies are design restrictions in production of licensed product and Research Development Departments' functioning abroad especially in multinational companies. Product design and development by using simulation softwares is a good example from the companies in the fifth maturity level.

Maturity level of the examined firms was observed to be very high (4.56 over 5) in Timekeeping. 53% of these companies are in the fourth level, which means that appropriate time plans were established but could not be totally implemented. 41% of the companies, which were in the fifth level had appropriate plans and implemented them with efficiently. Only 6% of the examined firms are in the second level and had few workers that did not attend startup - finishing time and time plans could not be efficiently implemented.

29% of the examined Turkish firms are in the second level in Performance Measurement. Although Manufacturing Departments of them had determined non-financial performance criteria, financial criteria are more important in evaluation. The firms that are in the third level denote 18% of the whole companies. All departments of them had performance criteria, which were parallel to company level objectives and were measure locally. 18% of the firms are in the fourth level and executed improvement studies by using performance measurements. Performance criteria in operational, tactic and strategic levels had been determined and used in order to observe the company's progress. However reward system did not exist in the firm. 29% is the percentage of the firms that were in the fifth level. They implemented reward system for well-performing employees. Improvements are made in case of failure in the company.

Management is generally committed to Lean Management System and provides full support to the employees in order to implement this system. These firms were in the fifth level and denote 52.9% of all examined firms. The companies that are in the fourth level had established action plan for Lean Management System, a team and a leader was responsible for implementations in the whole company. The percentage of these firms was 11.8. The companies in the third level denote 23.5% of the whole companies. These firms' executives had been trained in Lean Management System however no implementations were present. The executives of the rest of the companies are interested in Lean Management but needed more knowledge to get into action. However the executives of both the companies with foreign partners' and the foreign companies in Turkey were observed to be more trained and acting in a more organized way.

CONCLUSION

The results from the field analysis about Lean Production Management are summarized as follows:

- Suppliers Relationship Management was determined to be the most successful Lean Production Technique.
- The maturity level of implementation of Poka Yoke And Visual Controls were determined as 4 over 5, which was considered for the examine companies to be successful.
- The observations and responses implied that there was considerable amount of waiting, setup, WIP and inventory wastes that have to be eliminated.
- The maturity level of implementation in Industrial Housekeeping (5S) was determined to be 3.7 over 5. Since this is a very important aspect of Lean Production, the fifth level has to be achieved. 5S must become the part of our business.
- The maturity level in Setup Reduction was found to be 3.5 over 5. However the maturity level in Reduction of WIP is 3.65. These two variables, which are in related to each other, were not in contradiction. This indicated that the data, which was collected in field analysis, was reliable.
- The manufacturing companies in Turkey have to increase the cell penetration level, if they would like to improve their maturity level in Cellular Manufacturing.
- Kanban System was determined to be the least successful Lean Production technique. Because the manufacturing companies in Turkey could not be able to leave the Push Production Control System. In addition they hold excessive inventories in order to provide just-in-time deliveries.
- The low maturity level in both the Total Productive Maintenance (TPM) and the Flexible Workers, which was 3.29 over 5, implies that the implementations in these techniques have to be matured.

The results about the examined Strategic Management issues are explained below:

- The examined firms must implement team organization to their company structure permanently according to specific markets or specific product groups.

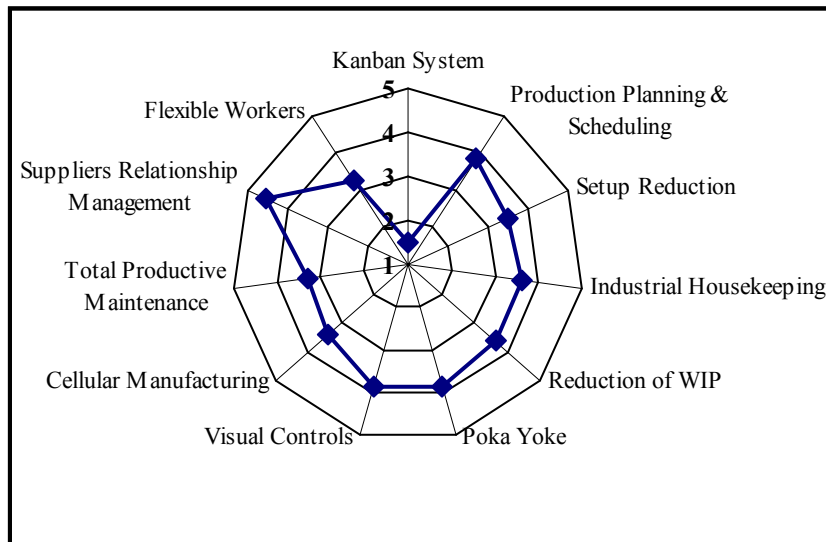


Figure 4. Radar Diagram of Mean Values of the Scores in Lean Production Management

Techniques

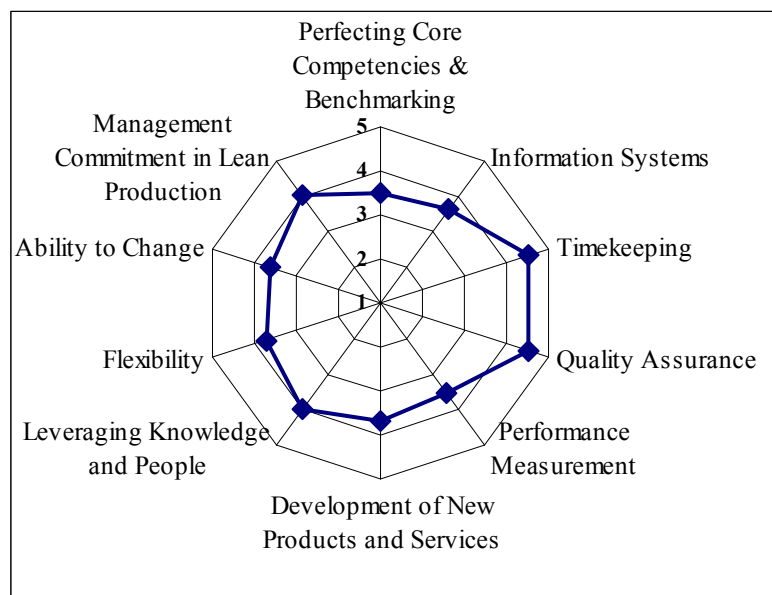


Figure 5. Radar Diagram of Mean Values of the Scores in the Examined Strategic

Management Issues

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