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Mapping Transformational Lean Maturity Model for Discrete Part Industries

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Abstract

The aim of this research is to determine the current and desired level of lean maturity level in the local manufacturing industries of Pakistan. This can certainly assist the local industry of Pakistan to optimize their processes, shrink wastes and increase the productivity by using this method. The developed lean assessment model evaluates the lean manufacturing and measures the leanness of the industries in terms of lean maturity model. It comprises of three categories. The assessment model consists of twelve factors on which the lean manufacturing is assessed which include leadership, communication, trainings, inventory, quality, continuous improvement, production processes, lean tools, maintenance, cost, on-time-delivery and energy-efficiency. A series of stages involved in developing lean assessment model, named as modified LESAT, are subdivided into four main phases: detailed literature review, development of lean assessment, data analysis and AS-IS and TO-BE analysis with gap identification. Current maturity level of the industries of Pakistan comes out to be 3.00, that managers and all the staff have knowledge about lean. The future state comes out to 4.00 that lean will be implemented to a greater extent and industry is striving to achieve more via continuous improvement. The gaps identified in many industries are weak in terms of energy efficient, inventory, quality, training, production processes and lean tools. The Pakistani industries must work and improve in view of factors identified. This will aid in achieving more productivity, better performance and excellent quality to survive in the market.

Keywords: *lean manufacturing, maturity levels, lean assessment, self-assessment tool, lean perspectives and factors*

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1. Introduction

In order to perk up the firm effectualness and efficiency, the manufacturing firms have to implement novel management and improved tools to meet the increasing challenges in the global market. For this reason, lean manufacturing tools and techniques have been adopted so far by many of the manufacturing enterprises which come in numerous different names. Nowadays, lean manufacturing has been adopted extensively in diverse enterprises and industries (Johanna et al., 2019; Norani Nordin, 2012). Manufacturing industries around the world have been facing challenges regarding technological, economic, environmental and societal changes. The best organizational strategy to bring the industry or enterprise in the forefront of the state of the art business excellence is to use lean practices in the manufacturing processes (Wong, Ignatius, & Soh, 2014).

The lean evaluation model can be generally classified into qualitative and quantitative assessments. In qualitative assessment, intangible type definitions are analyzed from diverse point of views. This includes Renault Production system and Lean Enterprise Self-Assessment Tool that was developed by Lean Aerospace Initiative (LAI) at MIT. Meanwhile, quantitative assessments include output of the performance by implementing lean manufacturing. Fuzzy Logic Concept and Data-envelopment-Analysis are the tools developed (Cherrafi, Elfezazi, Chiarini, Mokhlis, & Benhida, 2016; Helleno, de Moraes, & Simon, 2017; Maasouman & Demirli, 2015).

This research investigates the current and future state for lean maturity level in the manufacturing industries of Pakistan as basis for the improvement plan. It involves the development of lean self-assessment model known as modified LESAT tool for industries. On the basis of developed model survey conducted, data are collected and compiled to investigate the current and future leanness in industries for the suggested improvement plan.

2. Literature Review

2.1 Lean and Lean Manufacturing

Lean manufacturing or lean production is the new concept in the industry that can be traced back to Jim Womack, Daniel Jones and Daniel Roos' book, "The Machine". These

authors comprehensively described the Toyota production system which implemented the lean concept in their manufacturing system (Rauch et al., 2020).

Lean is defined as the "*elimination of waste*". Anything that has no effect or has nothing to do is regarded as waste. Many different industries have now implemented many lean tools, techniques and principles but few of them achieve significant achievement (Urban, 2015; Womack, Jones, & Roos, 2007). Womack, Jones and Roos (2007) identified the five key principles which organizations should follow as identification of value, value stream mapping, creation of flow of process, pull system of processes and look for perfection in work.

The lean manufacturing factors are the enablers to implement and enforce the lean principles. The acceptance of lean practices requires the alteration in design of job and also management of the workers (Farias, Santos, Gohr, Oliveira, & Amorim, 2019; Tortorella, Vergara, & Ferreira, 2017). Thus the selection of best and most appropriate lean practices; for the improvement of manufacturing and identification of wastes, is the most challenging and issue for the top management. From the past literature there have been at most hundreds of lean practices available (Büyüközkan, Kayakutlu, & Karakadılar, 2015). Some of the factors on which lean manufacturing depends are top management, leadership, lean tools, trainings and communication (Pius Achanga, 2005; Vinodh & Balaji, 2011).

A collective team work for finding and eliminating all kind of wastes from the organization is the background of lean manufacturing. Various types of lean manufacturing tools are available to confiscate efficiently all wastes (Gupta & Jain, 2013; Singh & Kumar, 2019). Kaizen is a Japanese term which means 'continuous improvement'. This refers to the activities that improve each and every function of the manufacturing organization (Kiran, 2020). Kanban system reduces time waste, inventory and space because parts are ordered when necessary. Conversely if parts come automatically without need, it will reduce profit. It also depends on consumer demand (Powell, 2018). The ultimate goal of the Just In Time (JIT) is to perform all processes on a part at one time and unerringly when there is a need for that part. Some authors stated that the reducing inventory, batch sizes, buffers and lead times are the components of the JIT (Dubey & Singh, 2015; Gupta & Jain, 2013). Total Productive Maintenance (TPM) is lean tool that is used to thwart inevitable machine breakdowns and downtime within a production cycle. The goal is to minimize the breakdown and to increase productivity. Preventive, corrective and predictive maintenance are part of it (Hartford, 2020). Total Quality Management (TQM) is

the enterprise level effort to improve the quality of the product being manufactured. Main goal is to improve the quality of the product in each and every step of manufacturing (Eniola, Olorunleke, Akintimehin, Ojeka, & Oyetunji, 2019; Hartford, 2020).

2.2 Lean Assessment tools

Leanness can be defined as the measure of the performance of the lean practices and level of lean adoption in an organization. It is investigates the lean status in an organization accordingly as lean, leaner and leanest (Nordin, Osman, & Adom, 2016). Diverse types of lean assessment tools and lean maturity models have been developed for the lean evaluation. It is desirable for organizations to develop a self-assessment model to assess the lean manufacturing (Maasouman & Demirli, 2015). The instruments adopted use different types of methods for the assessment, which are usually checklist and questionnaire (Urban, 2015).

The Lean Enterprise Self-Assessment Tool (LESAT) was developed by the Massachusetts Institute of Technology in 2012. This tool helps leadership in organizational transformation and achievement of goals. It is an executive level self-assessment of leanness of the present and as well as future or desired state of the organization. It has 54 lean practices divided into three sections: transformation and leadership; life cycle processes and enabling infrastructure. Each practice is scored on 5 capability levels.

2.3. Studies on lean assessment

Tiexeria Goncalves (2017) developed a tool that can evaluate each requirement in a design of assembly line of workstation. They developed a concept of "Hierarchy of workstations needs" to give priority to the requirements for substantial performance in workstation. The developed tool is in the form of check list which contains the best practices of the design. It was implemented in the assembly line of automotive workstation(Gonçalves & Salonitis, 2017).

Karvonen T. presented a proposal to convert software enterprises towards lean using lean enterprise self-assessment tool. The seven out of 54 principles of the LESAT were analyzed, modified and applied to Software industry. The results were compared with the LSD developed by Ericson Telecommunication Company. The LESAT mostly focus on the leadership and is comprehensive tool for evaluation of lean (Karvonen, Rodriguez, Kuvaja, Mikkonen, & Oivo, 2012).

Omogbai and Salonitis (2016) studied the print packaging industry in which main objective was to meet delivery times of the customers; therefore lead time is used for simulation in the SD software. The problem was modeled in software with job order and defects. The various relations among lead time, orders, WIP and defects are investigated. After lean assessment, lead time improved by 27% by increasing maintenance. Machine efficiency found out to be 73% and also 1.42 days of lead time (Omogbai & Salonitis, 2016).

The purpose of the Laoha and Sukto (2015) research was to assess electronic industry in the use of the 14 lean tools and techniques. The assessment criteria used were based on the research work of Aloha. Scoring system was based on the MBNQA approach and the criteria used two dimensioned performance & process. Process is assessment that consists of approach, learning, deployment and integration. It was concluded that lean assessment is crucial for finding gaps in productivity and eliminating waste and others (Laoha & Sukto, 2015).

Lean Maturity model was been developed by Muhammad Ali Maasouman to assess the level of lean in the manufacturing cell of seven axes. The research includes how overall leanness is measured by the organization and how overall leanness in manufacturing is determined by the maturity level model. They built the checklist system for measurement of indicators for in-depth analysis of lean. Their results showed that more leanness is depicted in level 1 and level 2 while leadership needs more improvements (Maasouman & Demirli, 2015).

In another study, the value stream-mapping was used to establish a manufacturing-sustainability-Index, MSI based on lean concept. The Delphi-Analytical hierarchy process was adopted to analyze the data. In the wooden furniture industry for case-study, the 11 indicators; inventory, cycle time, down time, transportation time, defects and change over time, were analyzed in three perspectives of environment, social and economic perspectives (Hartini, Ciptomulyono, Anityasari, & Sriyanto, 2020).

M.A. Alemi and R. Akram used fuzzy topsis process to find the leanness in production and manufacturing organization and implemented in the Parizen Santa Company. They developed the questionnaire, categorized in 11 parts and used ranking system. Their results showed that visual management system, management of complexity and variability, and customer satisfaction were identified as the most important components of lean performance (Akram, 2013).

Mourtzis, Papathanasiou, and Fotia (2016) identified the issue of nonexistence of rules that gives guidance and help to implement lean in industries. They summarize and formulated the rules that are applicable in busy nests environment. The methodology used was Moscow and color coding, and proposed a "Drawer lean rule idea". This helped the waste elimination and new employee training (Mourtzis, Papathanasiou, & Fotia, 2016).

Sherif Mostafa proposed a project based framework which include 4 implication phases to evaluate the lean implication initiatives. They identified the key factors and then formulate the rules to access the lean initiatives. They proposed that success of any initiative depends on two items one is lean initiative and second is organization practice. Results showed that a more agile and robust lean initiatives are that, which is easily understandable and comprehensive (Mostafa, Dumrak, & Soltan, 2013).

Ambra Galeazzo investigated the lean performance and financial issues by considering the managerial systems that was not considered before in literature. The study postulated that lean has impact on financial terms. The results showed that leanness has no influence on financial performance but the lean maturity has (Galeazzo, 2021) while Büyüközkan et al. (2015) studied and investigated the effects of financial and non-financial impact of lean tools and its implementation. Bayesian belief network analysis is used for the result.

Kyle B. Stone performed a non-experimental research to investigate the relationship between organization performance factors and leanness measures. He used Bruke-Litwin Model based on 12 factors. He concluded that a relationship existed between 3 parameters of performance indicators (Stone, 2012).

Lucus Gabriel Zanon addressed the links between lean practices and performance measure systems practices and suggested that both are responsible for higher organizational performance. On the basis of this, a framework was developed and implemented on the chemical industry. The 16 maturities level considering lean, PMS, organizational scenarios and improvements gates were defined. The framework provides a basis for managers to assess the PMS and lean in their organization towards more mature organization (Lucas Gabriel Zanon, 2020).

Similar assessment techniques have been used by other researchers such as systematic lean assessment tool for investigation of performance of the organization (Oleghe & Salonitis,

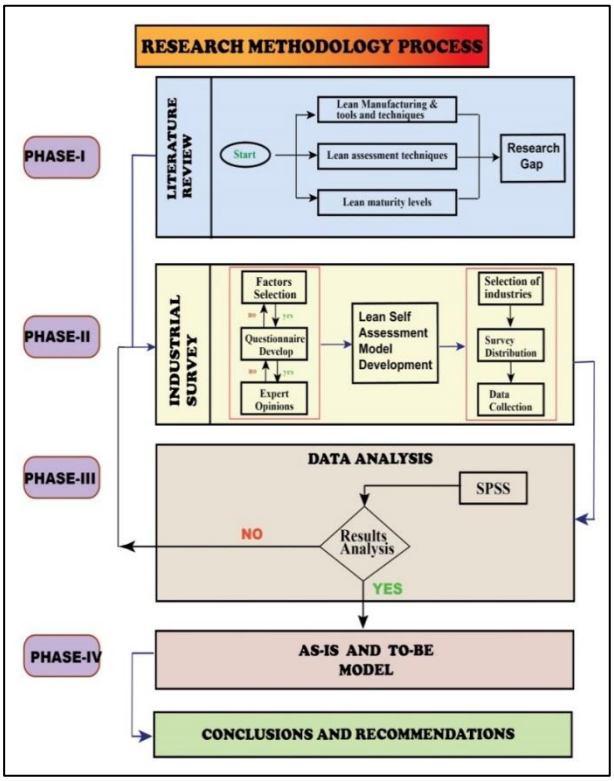
2018), level of leanness in the manufacturing organization through the fuzzy logic based tool for leanness measurement and decision making tool named FLBLA-DSS (Vinodh & Balaji, 2011), self-sufficient benchmark based leanness measurement tool to measure the level of leanness in the manufacturing firms (Wan & Frank Chen, 2008) and lean and green methodology based on the waste elimination in the production processes (Bento & Tontini, 2018; Bhasin, 2011; Verrier, Rose, & Caillaud, 2016). Moreover, Bhasin (2011), tailored 12 categories of lean philosophy for the assessment of lean and provided a technique for its measurement.. Meanwhile, Tortorella et al. (2017) presented a model for the assessment of relationship between lean manufacturing and socio technologic ergonomics

3. Research Methodology

The methodology is adopted from the various authors of lean with similar strategies such as Bento and Tontini (2018), Johanna et al. (2019), Maasouman and Demirli (2015), Setianto and Haddud (2016) and Urban (2015). Data collection and analysis was accomplished through quantitative approach. The methodology based on four phases as depicted in Figure 1.

Figure 1

Research Methodology



Phase I

Literature review. In this stage, a detailed literature review has been carried out. More than 65 research articles are reviewed and discussed. Each article was read thoroughly and summarized. Theme, results, strategy and techniques have been reviewed.

Understanding the context. In this stage, different lean tool, lean assessment techniques together with Lean Enterprise Self-assessment technique have been discussed. Starting from the basic definition of lean and lean manufacturing, lean principles and lean barriers have been discussed and identified.

Gap Identification. After the literature review and understanding the concepts and tools of the lean manufacturing, gap has been identified. This is the basis of research.

Phase II. The assessment tool for assessing the leanness of lean manufacturing in industries of Pakistan consists of various factors. On the basis of these factors a survey has been developed. Its different stages are:

Identification of lean manufacturing factors. With reference to the previous section, each research article is thoroughly studied and identified the lean manufacturing factors that affect and play role in lean manufacturing. These factors have been used further for lean self-assessment model.

Selection of Factors for Lean-Self Assessment. As described in the previous section that lean manufacturing factors have been tabulated from the detailed literature review. With experts' opinion and brainstorming most critical factors for lean manufacturing have selected. These are Leadership, Communication, Learning and Training, Quality, Continuous Improvement, Inventory, Lean Tools, Production Processes, Maintenance, On time delivery, Cost and Energy Efficient.

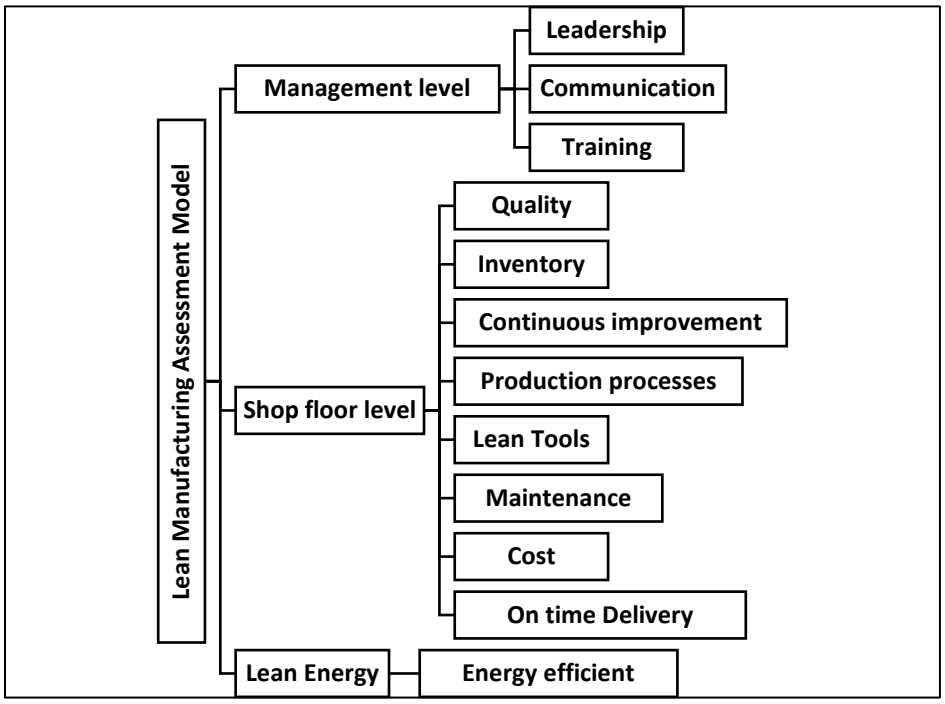
Modified LESAT tool for Discrete Part Industry (MLDPI). Based on the factors identified, a lean manufacturing self-assessment tool is developed for the assessment of leanness. It is based on the LESAT tool previously discussed. The assessment model consists of twelve factors which serve as the pillars of the assessment model. The LESAT tool is modified for the enterprise level. The modified LESAT for discrete part industries MLDPI is developed for assessing the lean manufacturing in industries producing

discrete parts. The twelve factors are categorized in three groups as Management level, Shop Floor level and Lean Energy as shown in Figure 2.

The Modified LESAT for Discrete Part Industry or MLDPI analysis consists of (1) AS IS analysis, (2) TO-BE model, (3) Gap finding and (4) Recommendation which are adopted from LESAT model.

Figure 2

Modified LESAT for Discrete Part Industry or MLDPI



Leadership. Leadership plays an important role for the lean manufacturing implementation together with fostering the skills and opportunities to the employees. Wilfred H ranked the leadership to be the most critical factor in lean manufacturing (Knol et al., 2018).

Communication. Communication means exchange of information with all stakeholders and with employees. For successful lean implementation, communication is necessary. Proper communication among employees helps better understanding and lean process of implementation in manufacturing areas (Mostafa et al., 2013).

Learning/Training. Training and learning programs must be conducted for the employees and managers. Resistance to lean improvement in workers and lean transformation in mangers is due to lack of lean knowledge (Mostafa et al., 2013).

Quality. Manufacturing industries must focus and strive to achieve the quality in their products and must standardize their processes according to international recognized standards, so to sustain in market (Gonçalves & Salonitis, 2017).

Inventory. Inventory is considered to be the malevolence for the manufacturing. As inventory needed for continuous operation of assembly, but too much inventory is bad and must be avoided. It also causes cost of handling but also loss in profit (Gonçalves & Salonitis, 2017).

Continuous improvement. Continuous improvement means that each person in the organization must work for the betterment and participate in the improvement activities. Continuous improvement is a slow and steady process which fetches substantial outcomes over the period of time (Büyüközkan et al., 2015; Setianto & Haddud, 2016).

Lean tools. Lean tools are the subordinate of the lean manufacturing implementation process. The various tools of the lean must be integrated in the practice to ensure high quality and waste eliminated process. Proper lean tools must be used (Mostafa et al., 2013).

Maintenance. Maintenance in lean is the proactive and preventive maintenance activities that should be carried out through total productive maintenance methods. In lean manufacturing, proactive maintenance is carried out to prevent the system for failure and to reduce the breakdowns. Schedule maintenance offers well organized activities, labor, resources and machinery (Omogbai & Salonitis, 2016). Total productive maintenance aims to eliminate all kind of losses, breakdowns and defects.

Production processes. For lean manufacturing the process of production must involve steps for waste elimination. Because it is the step on where the value is added in the material. The production involves minimum number of processes, low setup times, Efficient material handling and effective manpower (Doolen & Hacker, 2005; Vinodh & Balaji, 2011).

Cost. Cost is directly related to the lean manufacturing. With the implementation of lean tools, cost for production can be greatly reduced. Due to lean sales also effects because it enhances the product effectiveness and also increase the profits (Behrouzi & Wong, 2011).

On time delivery. It ensures that the delivery to the customer should be error free in terms of transport, packaging and the documentation. Late and inefficient delivery not only hampers the sales but also become the source of penalties to the organization (Chen, 2008; Galankashi, Helmi, Hisjam, & Rahim, 2018).

Energy Efficient. According to the type of work, workplace and environment should be designed to satisfy the worker need (height, size, reach, etc.). Excessive vibrations, noise, bad posture causes severe injury, cleanliness, and therefore they should be minimized.(Gonçalves & Salonitis, 2017; Verrier et al., 2016)

The questionnaire was developed for surveying the leanness in the Pakistan industries. It consisted of two parts: General Information and Survey Questions. General Information includes bio data of respondent while survey questions assess the lean manufacturing or leanness. Each factor is assessed further on 4-5 lean practices. The respondents rated the questions on 5 points Likert's scale for current and future states.

The value of leanness assessed via survey questionnaire is interpreted on the lean maturity level. A low lean maturity level showed that companies do not apply lean manufacturing to any extent While companies having high score of maturity have implemented lean manufacturing and tools in every process and departments of organization. The 5 maturity levels for this lean manufacturing assessment were patterned from the works of Rauch et al. (2020) and Setianto and Haddud (2016).

Figure 3
Lean Maturity Levels

Phase III

Following data analysis techniques have been implemented for analyzing the data.

Radar Charts. Multivariable data are visualized by the radar charts. They are used to plot and depict one or more groups of values.

SPSS. In this quantitative research, the questionnaire data obtained from the survey was of ordinal type and does not follow the normal distribution, therefore for these types of data non-parametric tests are performed (Harpe, 2015; Harry N. Boone, 2012). The non-parametric tests used for this research include skewness and kurtosis to check whether the data is normal or not. Normality tests are also performed for this purpose. Correlation, Spearman and Kandall's Tau are performed as suggested E.Mar, Lovena, Krisen, Vianee, and Girish (2012) and Harry N. Boone (2012).

Phase-IV

AS-IS and TO-BE Model. MLDPI assessment framework is developed for the lean performance evaluation. AS-IS model described current status of lean and lean manufacturing implementation. In gap identification, the critical areas were identified and displayed them through different problem solving techniques.

4. Results and Discussion

Table 1
Reliability Test

	N	%
Valid	71	100.0
Reliability Statistics		
Cronbach's Alpha	**N of Items**	
.921	**12**	

The reliability test in Table 1 shows high correlation among the variables. Similarly, ***Cronbach's alpha*** shows the consistency of the data. The Cronbach alpha is equal to ***0.921*** which shows high level of internal consistency indicating *perfect reliability.* Therefore, the 12 independent variables are closely related as a group and have a high positive correlation among them.

Table 2
Skewness and kurtosis

Descriptive Statistics					
Factors	Skewness Statistic	Kurtosis Statistic	Factors	Skewness Statistic	Kurtosis Statistic
Leadership	-0.738	-0.224	Production_ processes	-0.095	-0.498
Communication	-0.563	-0.083	Lean Tools	-0.440	0.515
Training	-0.669	0.441	Maintenance	-0.267	1.349
Quality	-0.302	0.899	Cost	-0.492	1.268
Inventory	0.070	-0.697	On Time delivery	-0.718	0.840
Continuous_ Improvement	0.279	-0.061	Energy Efficient	-0.989	1.192

The descriptive analysis requires a confirmation whether data are normally distributed or not. For this purpose, skewness and kurtosis tests were used as illustrated in Table 2. Skewness depicts whether data are *symmetrical or not*. By the rule of thumb, if skewness is between -0.5 to -1 or 0.5 to 1, data are moderately skewed (Ghasemi & Zahediasl, 2012; Hopkins & Weeks, 1990). In the given data, there are variables that are negatively skewed which indicate data skewed to the left and positively skewed data which indicate data skewed to the right. Meanwhile, value of kurtosis tells whether the data are heavy tailed or light tailed. Comparing the values of variables, there are light-tailed and heavy-tailed variables. The light-tailed are the data sets which lack outliers such as leadership, communication, continuous improvement, inventory, production process which are highly significant in measurement of dependent variable.

The Likert's scale data obtained from the survey were transferred to MS Excel where the mean values of each lean practices were calculated. These were tabulated through a radar charts shown in Figure 4 for visualization.

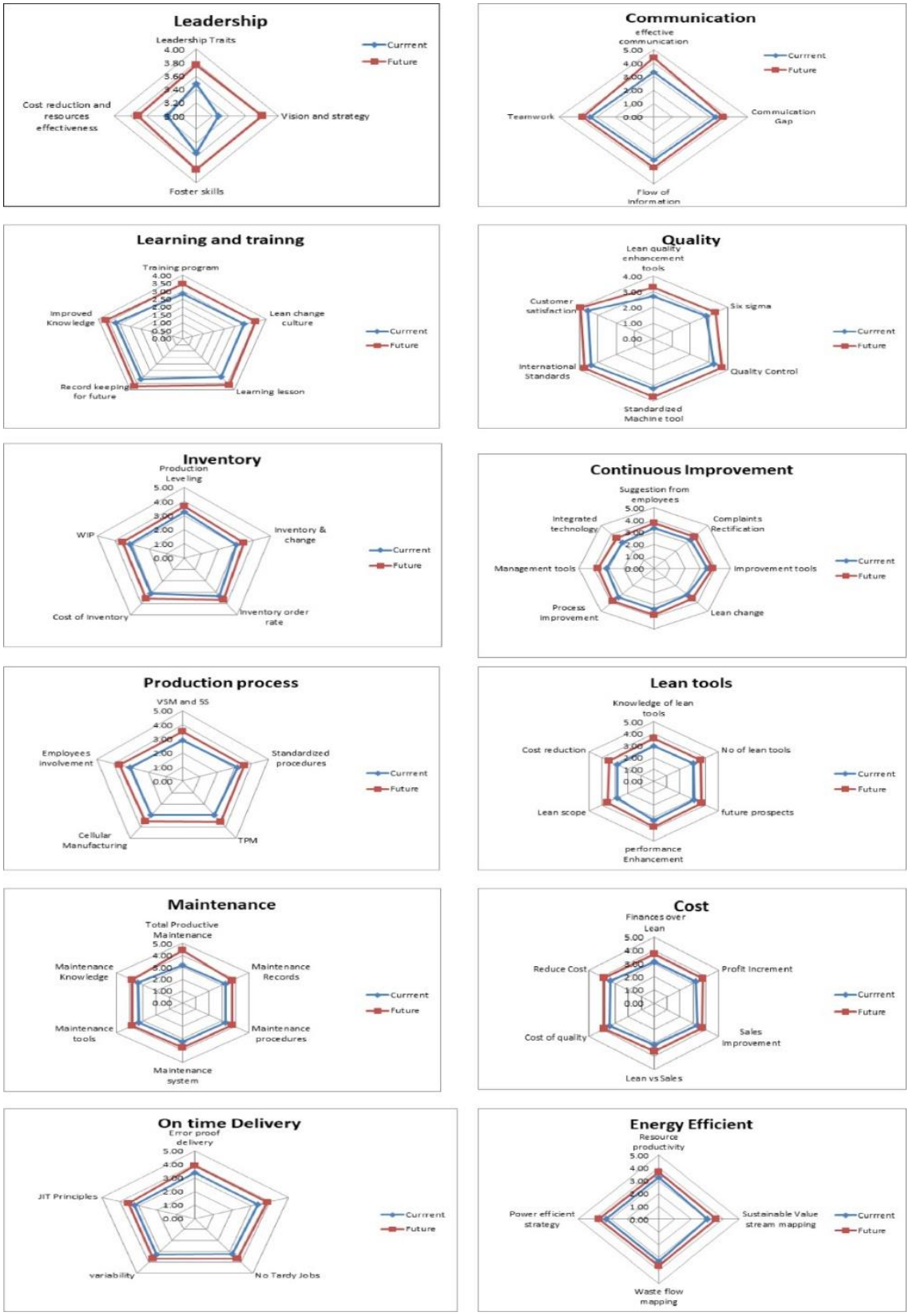
The following were the observations under the leadership:

Leadership Traits. Current state scored **3.48** which means that for a business to conduct successful projects leadership is needed and most of the firms are quite familiar with it. Future state scored **3.76** which mean that firms will continue to achieve more.

Vision and strategy. Current state scored **3.27** which means most company agree and are aware that if the senior management while future state scored **3.80** which mean that in the future firms would surely implement lean manufacturing.

Figure 4

Radar Charts showing score of each factor



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Foster Skills. Current state scored **3.55** which means that most companies agree to this that good leadership does play a vital role in fostering effective skills and knowledge enhancement amongst its. Future state scored **3.80** which mean that there are future improvements on workforce quality.

Cost reduction and resources effectiveness. Current state scored **3.35** while future state scored **3.70** which mean that in the future the companies would want to achieve cost reduction and resource effectiveness by implying leadership to attain success.

Communication plays a vital role in fulfilling organizational goals, objectives and obtaining success. These were the recorded quantitative analyses under communication.

Effective communication. Current state scored **3.34** which mean that communication does exist among the stakeholders of the company but is limited, while future state scored **4.39** which means that in the future companies want to improve communication

Communication Gap. Current state scored **3.32** which mean that the communication gap does exist but it's not a major issue which could disrupt the business processes while future state scored **3.69** which means that in the future companies will focus in reducing this gap to reduce the occurrence of any miscommunication that could disrupt the flow of business.low of information. Current state scored **3.20** which mean that flow of information does exist in some levels of organization but not all and many companies have exerted importance of it and many have not. Meanwhile, future state i.e. **3.76.**

Teamwork. Current state scored 3.35 which mean that in many organizations cross-functional teamwork has been successful and other organizations try to adopt communication to improve their teamwork as possible.

Under the Learning and Trainings, there was currently **2.83** score in organizations which means not all of the employees are familiar with the lean knowledge and are not getting trained. These training programs are being implemented in some areas of the organization but not all. In future, score of **3.46** implies that many organizations plan to implement training programs for future benefit of the company. Other observations under the training are as follows:

Lean change culture. Current state score of **2.96** implies that not many employees show resistance towards transformation. One reason could be because not many employees are

familiar with lean manufacturing methods but in the future according to the score of **3.46** when many employees are familiar with the changes and some might be greatly affected by it then employees might start to show resistance towards it.

Learning lessons. Currently this culture does exist as reflected by the scoreof **2.96** but not in all levels of organizations. In the future, the score of **3.65** implies that many of the organization would want to adopt a better culture from previous implementations which would help in the continuous improvements.

Future Record keeping. Current score (**3.18**) shows that in some organizations record is kept to evaluate the performance but not at all levels. However, to achieve success and learn from the past mistakes, the score of **3.75** suggests future record keeping.

Improved knowledge. The current score of **3.21** suggests that most organizations agreed that knowledge has been improved but not to a great extent. In the future state, score of **3.65** indicates that most organizations are willing to implement training to a greater level.

To increase customer goodwill and customer base product, quality really matters and lean manufacturing methods helps focus on it. The following were the observations in this parameter:

Lean quality enhancement tools. Accordingly, **2.69** score means that not all organizations are adopting quality improvement strategies, In the future (**3.28),** many organizations plan to adopt different strategies to improve their productions and quality.

Six sigma. Most companies are not using lean six sigma to reduce defect rates because mostly workforce of organizations are not familiar with it (score of **2.87)** but in some organizations it has been implemented and will be improved in the near future (score of **3.35).**

Quality control. Currently, most of the organizations have started to implement proper technology in most of their departments which have improved the overall efficiency of their workforce **(3.2)**. In the future (**3.69),** many organizations plan to use enhanced technology which helps multiple departments of each organization to improve overall work and reduce waste.

Standardized machine tools. Adopting machine tools have its advantages and disadvantages which many organizations have adopted to reduce waste and had been proven to achieve success (**3.17)**. In the future, many organizations plan to adopt different machine tools as to increase productivity like automated machines (**3.70**).

International standards. Accordingly, many organizations agreed (**3.38)** to the fact that they have adopted international standards like ISO and still many plans to adopt these in the near future (**3.73)**.

The following are the observations on the inventory:

Production leveling. Sometimes organizations prefer ordering extra-inventory to remain on the safe side but if ordered in large quantity a lot of materials are wasted. Currently, many manufacturers prefer maintaining inventory level (**3.27)** while future plan (**3.68)** shows that organizations tend to keep it this way.

Inventory and Change. Sometimes customized orders may affect inventory order size which was agreed by some of the manufacturers (**3.04).** However, in the near future many of the manufacturers are planning to control this variability (**3.46)**.

Inventory order rate. The current practices show that the ordering rate of many manufacturers have been controlled (**3.34)** but in the future some of the manufacturers plan on using better measures to control these factors (**3.66)**.

WIP. The WIP are part of assets in the balance sheets. Currently (**3.14)** the firms agree on this but in the near future, firms plan to adopt controlled WIP to improve lean manufacturing methods (**3.55)**.

Continuous improvement in the context of lean manufacturing is really important for success of a business. These were the recorded observations.

Complaints rectifications. Many of the industrialists agree with the fact that their organizations do resolve the complaints (**3.35**) and in the future the score of **3.73** shows that their organizations would continue to do so to improve.

Improvement tools. The score of **3.46** implies that many organizations have adopted tools and techniques and the future plans with corresponding score of **3.83** shows that manufacturers plan to adopt more tools.

Lean change. The current practices as reflected by the weighted mean of **3.07** mean that not all of the personnel have the authority to implement change but after a few meetings and discussions lean changes can be implemented if these suit the organization and its workforce.

These are expected to continue in the future as evidenced by weighted mean of **3.54** which shows most organizations would make lean changes where necessary but would not prefer giving authority of change to the majority.

Management tools. The weighted mean of **3.15** attest that these tools are being implemented in some areas of production in some of the organizations. Similarly, many leaders are aware of these tools but have not yet implemented them which are addressed in their future plans with a weighted mean of **3.73** that many organizations would want to adopt these lean management tools as possible.

Integrated technology. Currently, ERP systems are not fully employed in each level of organizations ($\bar{X}$=**3.00)**. But the companies are considering the use of ERP software to enhance their lean manufacturing methods evidenced by a weighted mean of 3.52.

In lean manufacturing methods, manufacturers focus on using production processes that would reduce waste and ensure quality. The following were the analysis of the various calculations.

VSM AND 5S. The calculated weighted mean of **2.90** implies that most of the manufacturers did not focus on VSM and 5S which can be attributed to negligence. While some of the organizations have adopted it, many organizations plan to adopt it as reflected by the weighted mean of **3.54**.

Standardized and procedures. The manufacturers have started using standardized procedures and operations to achieve lean efficiency as possible ($\bar{X}$=**3.18**) but future plans show many organizations plan to adapt more advanced version of these tools ($\bar{X}$=**3.58)**.

Cellular Manufacturing. Cellular manufacturing is based on lean production method as it helps business to produce waste free products. The weighted mean of **2.96** indicates that not many organizations were **aware** of the concept of cellular manufacturing but with advancement and awareness in the near future ($\bar{X}$=**3.51)** many organizations plan to implement cellular manufacturing in maximum areas of productions.

Employees' involvement. In many organizations, employee do get involved to improve the services and productions ($\bar{X}$=**3.07)** but future plans are in place for the manufacturing departments plans to use multiple innovative tools to improve employee involvement ($\bar{X}$=**3.70)**.

For the implementation of any method or tools, knowledge about them is necessary. The following were the recorded observations on lean tools.

Knowledge on lean tools. Results show that few employees were familiar with lean tools but many organizations plan to educate the employees and implement the tools ($\bar{X}$= **3.61)**.

No. of lean tools. On average ($\bar{X}$=**3.04),** the organizations have implemented at least 5 or more lean tools in their organization. But some have only started using them in some areas of the organization but plans to implement more in the near future ($\bar{X}$=**3.58).**

Future prospects. With the weighted mean of **3.08,** the managers of organizations agree to the fact that they are using multiple lean tools to increase efficiency of lean methods. With a weighted mean of **3.69,** managers also agree to implement more in the future. These organizations are in a growth stage; lean tools that are in use are in experimental phase.

Performance Enhancement. The weighted mean of **3.30** implies that implementing lean tools have improved their profit and time. Meanwhile, the weighted mean of **3.85** also implies that many of these enterprises agree to improve and enhance the lean methods to implement more tools. Since few tools are used, enhancement is average.

Lean Scope. On average. the **2.83** score tells that not all departments are using lean tools but organization look forward in implementing lean tool to enhance their production methods as evidenced by mean score of **3.5**.

Cost reduction. With the main purpose of lean tools to reduce costs, the average mean score of **2.82** further reflect that besides their agreement on the purpose of lean tools, mostly organization workforce are not familiar with lean tools. With further awareness and their implementation, these costs can be reduced in the near future as reflected in the average score of **3.41**.

Maintenance of production processes keeps the whole department error free. Under this variable, the following were the calculated data.

Total productive maintenance. On average mean score of **3.18**, the organizations agree that their systems have been configured but still plan to implement system configuration in the future ($\bar{X}$=**4.39)**.

Maintenance records. Results of the survey show an average mean score of **3.23** that many organizations keep maintenance records for better understanding. Their future assessment resulting to mean score of **3.73** states that for improvement in performances, organization plans to keep all the maintenance records.

Maintenance procedures. In accordance to the survey score **3.27,** most of the organizations procedures and standards are based on OEM. But for now it's being implement in limited areas whereas in the future, survey score **3.72** shows that companies plan to implement the procedure based on OEM in almost all the departments.

Maintenance systems. Many of these measures still exist in the organizations ($\bar{X}$=**3.30)** and with the help of lean tools, organization plans to focus more on these maintenances in the future ($\bar{X}$=**3.79)**.

Maintenance tools. Many organizations do provide lean tools to their workers on each floor but with limits ($\bar{X}$=**3.34**). In the future, many organizations plan to improve their service to their and supply all necessary tools ($\bar{X}$=**3.82)**.

Maintenance knowledge. With the current average score of **3.37**, not all employees are familiar with maintenance knowledge creating limits on each procedure. To reduce this limit, organizations plan to spread awareness about maintenance to improve and enhance lean methods in the near future ($\bar{X}$=**3.80)**.

All organizations focus on reducing costs to obtain competitive advantage. The following are the observations on these.

Finances over lean. Many organizations do not spend money on training on lean knowledge because only few organizations are aware of its importance ($\bar{X}$=**3.13).** Therefore, many organizations see themselves spreading awareness about lean tools and incurring costs on staff lean trainings in the future ($\bar{X}$=**3.75**).

Profit increment. With the mean score of **3.24,** many agreed that lean manufacturing has positive effect on the profit of the organization. Many manufactures are sure of the fact that in the future ($\bar{X}$=**3.75)** lean manufacturing methods would continuously improve their performance and profits.

Sales improvement. Many organizations are seeing positive change in sales after improving their communication and relations with the customer ($\bar{X}$=**3.32)** and plans to further increase these communications to improve sale in the near future ($\bar{X}$=**3.73).**

Lean vs. Sale. With an average mean score of **3.15**, manufacturers believe that lean and sale have linear relationship because lean methods help enhance business performances. Once these performances increased, sales would automatically increase as lean tools affect each and every factor. Therefore, its effect will continue in the future ($\bar{X}$=**3.65)**.

Cost of quality. Organizations agree on reasonable cost for good quality ($\bar{X}$=**3.45).** In the future, most organizations wish to change low quality of their products and agree to pay more for best quality ($\bar{X}$=**3.87).**

With regards to the 'On time Delivery', the following were the observations.

Error proof delivery. All organizations try to deliver their products on time according to the demands of the customers ($\bar{X}$=**3.35).** Certain drawbacks are taken in concern and are supposed to be improved in the near future, so many companies plan to improve their service and satisfy their customer as possible ($\bar{X}$=**3.89).**

No tardy jobs. Management try their best to eliminate any tardiness ($\bar{X}$=**3.24).** Tardy jobs are close to zero in organizations as many have found way to improve it but in the near future ($\bar{X}$=**3.65)** many organizations plan to fully eradicate tardiness.

JIT principles. Most companies have come to an agreement with their suppliers to adopt JIT but others are still working on it ($\bar{X}$=**3.24).** Therefore, in the future ($\bar{X}$=**3.58),** many organizations wish to fully adopt JIT due to its benefits.

Applying "lean" principles to reduce energy consumption and waste, manufacturers can see significant cost savings. These are the observed practices and future directions of the companies.

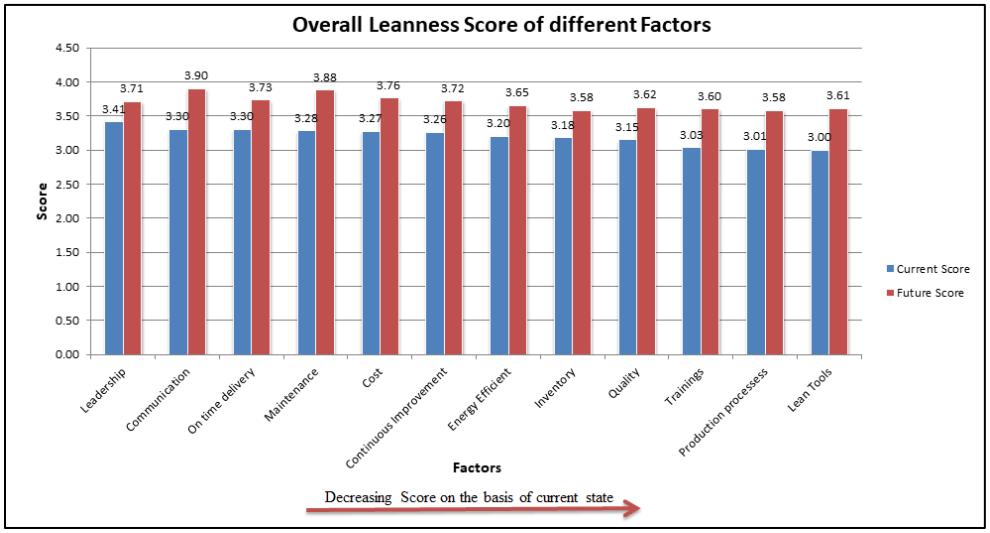
Resource Productivity. Some industries use resource productivity and energy efficiency while many were currently not aware of if ($\bar{X}$=**3.27)**. Therefore, in the near future ($\bar{X}$=**3.68)**, many companies wish to adopt it.

Sustainable value stream mapping. These lean tools have been implemented in some areas of organizations ($\bar{X}$=**2.99)** but many organizations has future plans of training their staff to improve water consumption and emissions ($\bar{X}$=**3.55)**.

Waste flow mapping. To make lean methods efficient, organizations have some good practices of following things ($\bar{X}$=**3.28).** Many organizations still want to improve their water and energy consumption slowly and gradually by implementing it on greater level in the future ($\bar{X}$=**3.65)**.

Power efficient strategies. Many workers and staff of the organizations try to adopt these methods as much as possible to enhance their production processes ($\bar{X}$=**3.28)** but in the near future, organizations want to implement leans methods at higher level ($\bar{X}$=**3.73).**

Figure 5
Overall leanness score of factors in descending order of current state



Leadership, communication and on time delivery are amongst the top three which the lean manufacturing depends as evidenced by weighted means of **3.41**, **3.3** and **3.3,** respectively. Leadership initiates and opens doors of opportunities for the lean while communication helps in better transfer and flow of information from start to end. On time delivery is linked with the profit and customer satisfaction.

The factors that are given least attention in the industries are energy efficient, inventory, quality, training, production processes and lean tools with mean scores of **3.2, 3.18, 3.15, 3.03, 3.01** and **3.00,** respectively.

Table 3
Overall Leanness score and maturity level of the Industries

	Current State	Future State
Overall leanness	3.20	3.70
Round off score	3	4
Lean maturity level 3	Workers and all the staff have knowledge about lean and they try to adopt the lean Manufacturing as far as possible	
Lean maturity level 4	Lean has been implemented to greater extent and industry is striving to achieve more via continuous improvement	

Overall, the average score is between '3.20 to 3.70'. Considering all the other factors, it can be concluded that most of the organizations are fully aware about leanness methods and were trying their best to implement leanness related tools in their organization to achieve success.

5. Conclusion

Organizational improvements, value that customer receive and identification of wastes, whether inside or outside, are directly related to lean. Based on the results gathered from the MLDPI leanness assessment tool, the overall score obtained is 3 for current practices while 4 for future implementation plans. Some of the organizations which fully implemented leanness tools have achieved competitive advantage and large customer-base resulting to increased sales, better and smooth production flow and improved overall performance. For the future state, it is slightly higher than the current which means industries will still work on lean. The reasons for not improving much are the lean barriers. People do not want to accept the change and want the system to run on status quo.

The gap found between AS IS and TO BE model is the value of one. It means that industries in future will move to the next maturity level. They will be achieving more via continuous improvement and will be implementing more lean manufacturing in their production as well as management level.

The results of the study could be accentuated that a model, such as modified LESAT for discrete part industry, could assist researchers and managers as a reliable and sustainable setting for manufacturing performance practices towards more mature lean organizational state.

Based from the results of the study, the following are recommended:

- Applying "lean" principles for reduced energy consumption and waste, manufacturers can see significant cost savings. In addition to tracking energy flow, the Lean Energy Practice can also provide maintenance and sustainability initiatives for long-term savings. Its Total Productive Maintenance Services, a critical adjunct to "lean" manufacturing, is focused on waste elimination, preventing equipment breakdowns - a proactive approach that prevents any kind of process interruption before maintenance is needed.
- The first thing is to maintain principles of lean manufacturing, making value flow at the pull of the customer which is the idea of Just in Time (JIT) production. This will remove the main cause of inventory that is overproduction. Look at factory and cell layout, balance the production processes to ensure that work in process does not build up between processes. It is not important to run every machine as fast as it can be run. At the end of the day, companies only need to make things as quickly as the customer want, not faster. Take time and Kanban can be used to help ensure the balance in processes and prevent the buildup of inventory.
- Quality management is a core lean manufacturing principle however improving quality assurance even further for small and large manufacturers alike can be achieved by adopting Six Sigma techniques, Quality management and strategies. Although lean manufacturing is best known for its JIT production efficiencies, it also includes a set of quality management principles. These principles, therefore, strive for quality built into product and process design. Mis-assembly errors are reduced by Poka-yoke and intelligent automation will detect process malfunctions or product defects immediately and automatically shut down a machine.
- This study shows that training for continuous improvement and new opportunities should be given about the common improvement method. Indeed it is advisable to coordinate any training on improvement as well as new skills, tools and method needed by both the organization and employees involved in the conduct of JIT. When successfully implemented, the system establishes the problem-solving culture where teams and groups continuously learn, adapt and improve within the organization.
- Various lean tools can be employed in industries. These tools are most effective if these are implemented together but these can also be implemented individually. The selection of right tool is very crucial. Not every tool brings about change and not every tool is fit for every job therefore right tool must be selected. Utilizing lean practices to spot and rectify a bottleneck saves companies’ resources. Depending on the type of bottleneck, there are several things to

address it. For example, bottlenecks caused by inefficient processes can be fixed through streamlining and improving those processes; if it is instead caused by a lack of resources, there may need to hire more people or purchase technology to make existing resources go further. Meanwhile, value stream mapping is adopted in a variety of industries, including manufacturing, finance and healthcare. This norm takes all the people, processes, information and inventory necessary, and displays them in a flow chart to get an overview of the business. Lean tools and principles can be applied to various industries of Pakistan. Some of the top industries looking for professionals with expertise in Lean methods include aerospace manufacturing, employment services, engineering services, control system, measurement tool manufacturing and medical hospitals.

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