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Utilizing Employee Stress to Establish Guidelines for Managing Personnel During Lean Transition

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To the Graduate Council:

I am submitting herewith a thesis written by Nezhad Naim Jallal Hossiney entitled "Utilizing Employee Stress to Establish Guidelines for Managing Personnel During Lean Transition." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Industrial Engineering.

Rupy Sawhney, Major Professor

We have read this thesis and recommend its acceptance:

D. Kong, Robert Ford

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

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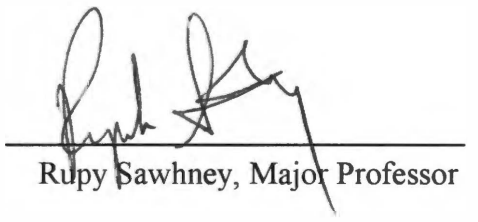

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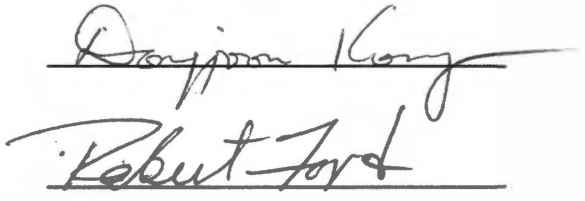

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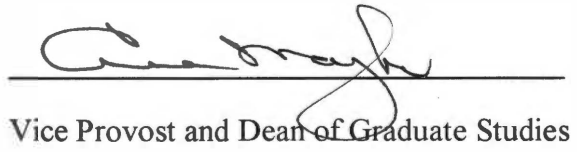

Vice Provost and Dean of Graduate Studies

Thesis
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Utilizing Employee Stress to Establish Guidelines for Managing Personnel During Lean Transition

A Thesis

Presented for the

Master of Science Degree

The University of Tennessee, Knoxville

Nezhad Naim Jallal Hossiney

May 2006

Dedicated to my grandmother,

Monavar Soheili

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ABSTRACT

Employee resistance has been one of the many primary obstacles during Lean execution. Employee stress is a principal outcome of resistance when implementing Lean systems. This research is directed towards finding the relationship between employee stress and Lean. The hypothesis states-Lean implementation increases employee stress.

The research methodology involves investigating employee stress during various phases of Lean. This research proposes three phases of Lean that are- Lean Introduction Phase, Lean Implementation Phase, and Lean Refinement Phase. Surveys are used to collect data for the study. Two questionnaires are used 1) Lean Environment Evaluation Profile (LEEP) 2) Work Stress Profile (WSP). A pilot test is conducted using these two questionnaires. The results from the pilot test are used to calculate the sample size; the standard deviation was 13.06, with an acceptable confidence level of 95% and maximum error of 3. The sample size was calculated to be 72.80 rounded up to 73. A standard data collection procedure is designed to ensure consistency of data collection throughout the study, which included identifying the companies for the study. Hypothesis testing, correlation analysis, regression analysis, and descriptive and graphical analysis are used to analyze the data collected.

Correlation analysis and regression analysis indicates that there is a negative correlation between employee stress and Lean. There is a - 0.531 correlation between employee stress and Lean. The coefficient of determination (r^2) is calculated to be 0.28. The following regression equation was obtained from the analysis,

Employee stress = 190 – (0.396) x (Lean)

Hypothesis testing resulted in refuting the null hypothesis that was

H_0 = Lean increases employee stress.

The results from data analysis indicated that as Lean progressed through various phases the employee stress reduced, however there is a slight increase in employee stress at the beginning of every phase as shown in figure 10.

The research made the following conclusions based on the analysis of the data collected using the LEEP and WSP questionnaires.

1. There is a negative correlation between employee stress and Lean
2. Employee stress is different in the three phases of Lean
3. Various Lean principles have a different impact on employee stress in various phases of Lean

This research identified areas for future research and suggested the following hypothesis: Human aspects of Lean are more stressful than technical aspects of Lean.

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Chapter One

Introduction

1.1 Introduction

Lean is a methodology that believes in effective and efficient utilization of resources by eliminating waste. Lean is adapted from Toyota Production System (TPS), which was originally developed by Toyota Motors Inc. This methodology is based on sustaining a culture of continuous improvement through two core symbiotic mechanisms: technical aspects and personnel aspects. These two core mechanisms are further decomposed into what are four pillars of Lean. These pillars are production system, process capability, people, and culture [35]. All of these pillars are dependent on the cooperation of the workforce for successful implementation of Lean. Two of these pillars (people and culture) are completely dedicated to the personnel aspects. The other two pillars (production system and process capability) depend heavily on the interaction of the personnel and technical aspects of Lean implementation.

1.2 Problem Statement

Managers frequently face resistance from employees to change when implementing Lean Systems. Handling employee resistance has been one of the more difficult issues for an organization implementing Lean. This has resulted in many organizations not achieving anticipated results. Often times these changes have resulted in short term improvements, however, due to lack of employee involvement these changes did not result in long term improvements. Research has indicated that "backsliding" is one of the top issues in Lean. This backsliding is primarily resulting

from employee resistance to change. Backsliding is a term that indicates that an organization cannot sustain the changes it has implemented [11]. Further, this phenomenon is directly related to the personnel aspects of Lean as it is the employee resistance to change that is the root cause of backsliding. There have been numerous attempts to better understand and model human resistance. Currently, industry does not have an accepted approach that allows industry to directly deal with employee resistance by providing management guidelines. Lean, which can significantly improve productivity and quality, can also influence employee stress. This research proposes to utilize employee stress to develop management guidelines for implementing Lean.

1.3 Research Methodology

Research is split on the impact of Lean on employee stress [25]. There are varying views highlighting the potential positive and the negative impact of Lean on employee stress. For example, small lot size production; a principle of Lean, can have negative impact on the operator because it increases the frequency of setups or have a positive impact because production is more aligned with customer demand. This research investigates the relationship between employee stress and lean implementation. Further, the proposed research investigates employee stress through the three phases of lean implementation. The implementation of lean manufacturing consists of three consecutive phases: Lean Introduction Phase, Lean Implementation Phase and Lean Refinement Phase. Lean Introduction Phase is the phase in which the organization announces its intention to implement Lean and the employees are introduced to the various tools and concepts of Lean. Lean Implementation Phase is the phase in which employees use the Lean tools and concepts in improving their work environment. Lean Refinement Phase is

the phase in which employees continuously improve the systems that have been implemented.

Each phase of Lean impact the employees in a different manner. For example, Lean Introduction creates anxiety in the employees because of the pending changes in the organization and the employee expectations. Lean Implementation creates stress in the employees for many reasons including implementing change while maintaining production. Lean Refinement could create stress in employees because immediate results were not achieved. The following seven steps outline the proposed research methodology.

1. Lean Survey Development: The objective of this survey is to assess employee perception of the degree to which Lean has been implemented in their organization. This is critical information as it allows this perception to be translated into the three phases of Lean. This survey consists of 15 questions based on basic Lean principles: flow, employee empowerment, employee, involvement, workplace organization, visual control, material handling and movement, quality, customer delivery and lean culture.
2. Work Stress Profile: The objective of this model is to quantify employee stress in an organization via a survey. The focus of the survey is to exclusively assess workplace related stress. The Work Stress Profile; a model published by Phillip L. Rice will evaluate a snap shot of employee stress.
3. Pilot Study: The objective of the pilot study is to utilize the two surveys above to develop relationships between the degree of Lean and employee stress. In addition the pilot study is utilized to determine the most effective means of data collection.

The results from the pilot study will be utilized to refine the procedure for conducting these surveys.

4. Study Design: The objective is to define the target audience and determine the appropriate sample size. The sample size is crucial for statistical significance of the study.
5. Data Collection: The objective is to have a standard data collection methodology for the study. This includes identifying organizations, introducing the audience to the purpose of the study and guide data collection.
6. Data Analysis: The objective is to utilize inferential statistics as the basis for the data analysis. This includes hypothesis testing, correlation analysis, and regression analysis. Descriptive statistics and graphical analysis will is used to analyze the data and present the conclusions from the analysis.
7. Report Research Findings: The conclusions are reported.

1.4 Research Contributions

The contributions of the proposed research are as follows:

1. Identify past research associating employee stress to Lean.
2. Identify the relationship between employee stress and Lean
3. Identify the level of stress in each phase of Lean
4. Identify Lean principles that influence employee stress in each Lean phase
5. Management guidelines for managing employees through different phases of Lean

1.5 Hypothesis Development

It is hypothesized that the progression of Lean implementation through it's various phases' leads to the increase of stress levels in employees.

The following hypothesis is proposed

H_0 = Lean implementation increases employee stress

H_A = Lean implementation does not increase employee stress

Other anticipated findings from the data collected and statistical analysis will assist support the contributions of the research are as follows

- Employee stress in each phase of Lean
  - Employee stress in Lean Introduction Phase, Lean Implementation Phase, and Lean Refinement Phase.
- Lean principles that impact employee stress in each phase
  - Key Lean principles: Technical aspects and Human Aspects that impact employee stress.
- Management guidelines for Lean implementation based on employee stress.

1.6 Research Organization

This research is organized into four remaining chapters as shown in Figure 1. Chapter 2 provides the literature research and an explanation for the hypothesis development. Chapter 3 provides an explanation of the research methodology used for this study. Chapter 4 presents the results of the data analyses and discuses the results. Chapter 5 draws conclusions, summarizes the contributions of the study, and suggests areas for future research.

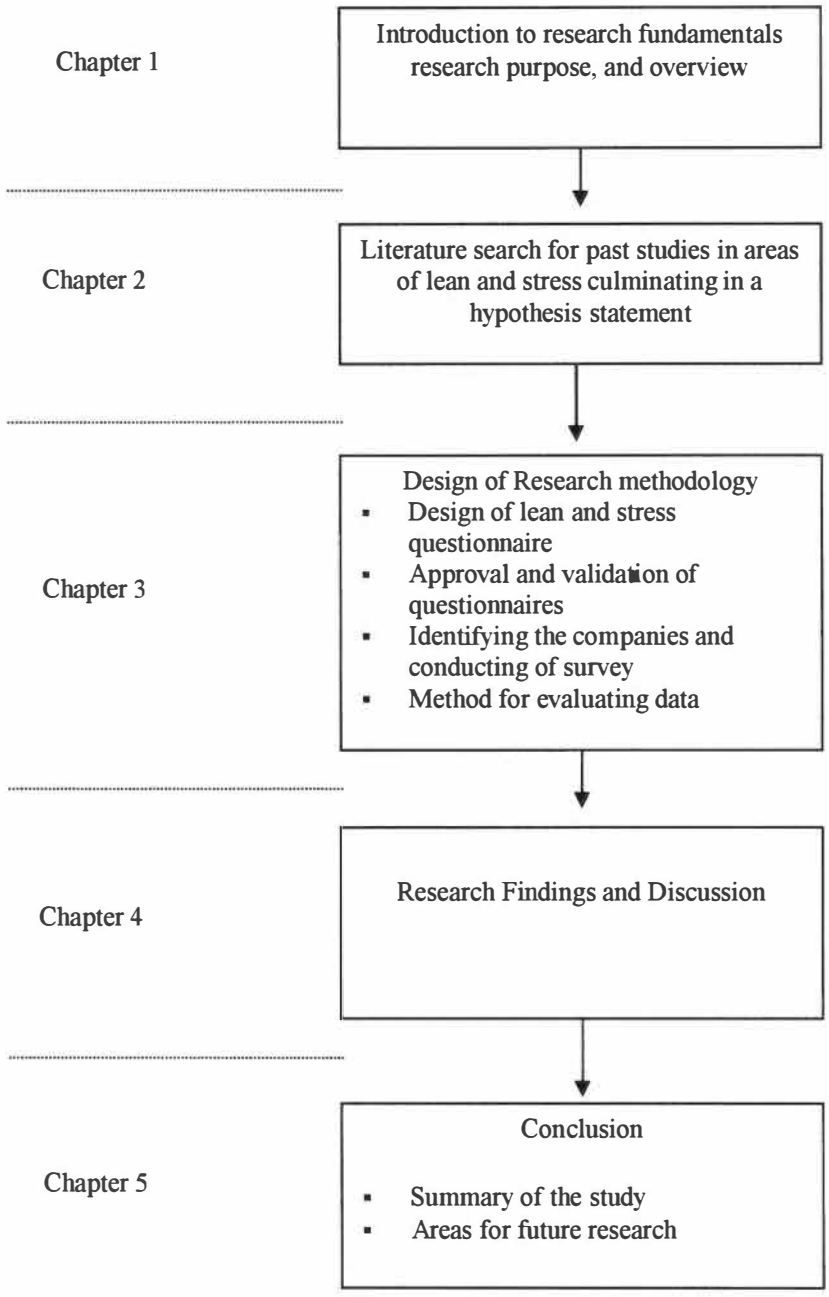


Figure 1: Steps involved in administering the research

Chapter Two

Literature Research

An extensive literature search was conducted to identify all previous studies that attempted to link Lean to employee stress. Manufacturing and production engineering publications as well as various areas of human sciences dealing with psychological and physiological aspects were investigated to find scientific work relating Lean to employee stress. Literature search revealed there was no substantial research done in the area of Lean and employee stress. However, there were article available that proposed the advantages and disadvantages of Lean on employee stress. This chapter includes the definitions of Lean and employee stress and statements from key articles relating Lean to employee stress.

2.1 Define Lean Manufacturing Principles

In the present high competitive environment, traditional production techniques are giving way to a new set of production paradigms. These paradigms include Lean Manufacturing and Agile production. So innovative are these new production and management practices that some scholars have depicted them as post-Fordist; a term that signifies elimination of all the negative aspects of Henry Ford's mass production system [32, 34].

The best-known post-Fordist production paradigm is the Toyota Production System (TPS). This system is the basis for Lean Manufacturing (also called as Lean). TPS; a new system of manufacturing was developed by Eiji Toyoda and Taiichi Ohno. TPS is an assembly line manufacturing concept for Toyota Motor Company Inc. that

combines the advantages of craft manufacturing and mass production (Toyota) [27]. The sole purpose of TPS is "to get the right things, to the right place, at the right time, the first time, while minimizing waste and being open to change" [27]. TPS is credited for enhancing the competitiveness of manufacturers over the past decade because when tailored properly for a unique organization, TPS can substantially cut costs. Only a small group of organizations have successfully duplicated the results that Toyota was able to achieve.

The pressure on manufacturers to implement these new paradigms is driven by a confluence of pressures including but not limited to market dynamics, competition, and shareholder demands. In many segments of manufacturing, TPS has been viewed as the key to operational competitiveness [30]. However, TPS fails to provide anticipated results because most of the Lean execution programs are targeted at implementing technical systems with no attention given to human aspects [17, 20].

Lean as explained by Michel Baudin, is 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 support tasks. Lean is a "pursuit" rather than a system. Generally once a Lean system is implemented, it is only subjected to minor tweaking. However, Lean is and should remain a work in progress [28]. Its practitioners, starting with Toyota, are constantly reinventing it. It is a "pursuit" by definition due to its dynamic nature. The key to any successful Lean undertaking is to have a sustained culture of continuous

improvement comprising of technical and human aspects as adapted from TPS. Figure 2 shows in detail the four main pillars of Lean as derived from TPS. The main pillars are:

1. Production system 2. Process capability 3. People (employees) 4. Culture

In Figure 2 the degree of impact employees have on these four pillars during any continuous improvement program is illustrated by the shaded areas. While it stands out those employees have the most impact on the culture of the organization this research focuses on the third pillar, which is 'People'. However, it must be noted that each pillar individually does not result in the successful implementation of a Lean program. The effectiveness of the Lean Manufacturing system lies in the integrated implementation of all four pillars. Production systems and process capability contribute to infrastructure improvement in the organization [14, 22].

A group of eighteen organizations involved in Lean Manufacturing and/or TPS like programs were tasked with investigating the content of their Lean training. Figure 3 shows the results of the investigation. Results show that 67% of the organizations involved in Lean programs concentrated solely on implementing technical aspects of the program. Technical aspects include concepts like Total Preventive Maintenance (TPM), visual controls, one-piece flow, cell layout, and process mapping.

Results also indicate that only 25% of the organizations solely concentrated on human aspects of Lean implementation. Human aspects of Lean include cross-training skills, identifying roles and responsibilities, developing multi-disciplined team environment, developing and training Lean Manufacturing managers and having a comprehensive communication system. counterproductive [5, 12].

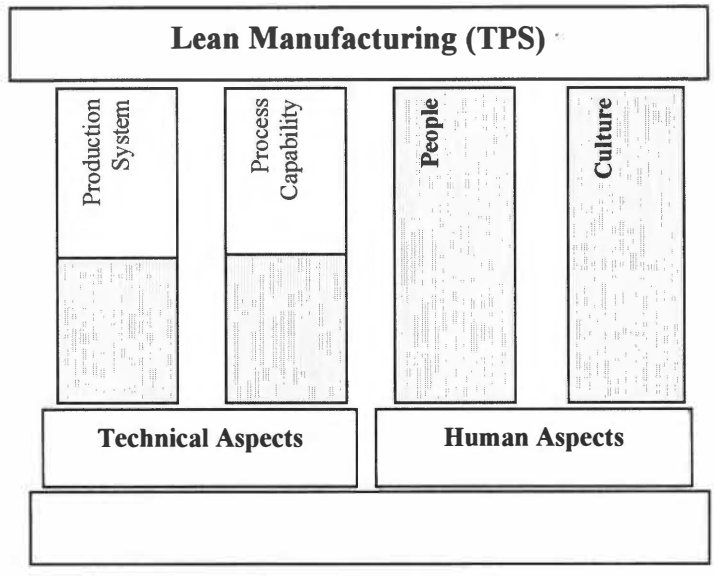


Figure 2: Four pillars of Lean

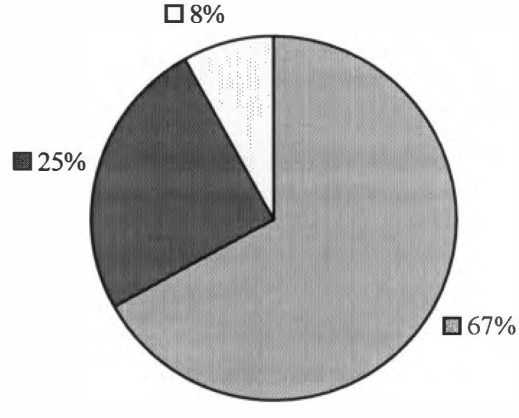


Figure 3: Percentage of organizations spending time implementing technical issues and human issues during Lean execution

It is interesting to note that only 8% of the organizations concentrated on technical as well as human aspects of Lean.The performance of the organization is measured by three criteria these criteria being; cost, quality, and delivery.

Figure 4 shows the interrelationship of waste and performance metrics in a continuous improvement program [35, 30]. Seven wastes have been identified as having a negative impact on the organizations performance metrics [26]. The seven wastes identified are:

1. Inventory
2. Processing
3. Waiting time
4. Motion
5. Transportation
6. Overproduction
7. Defects

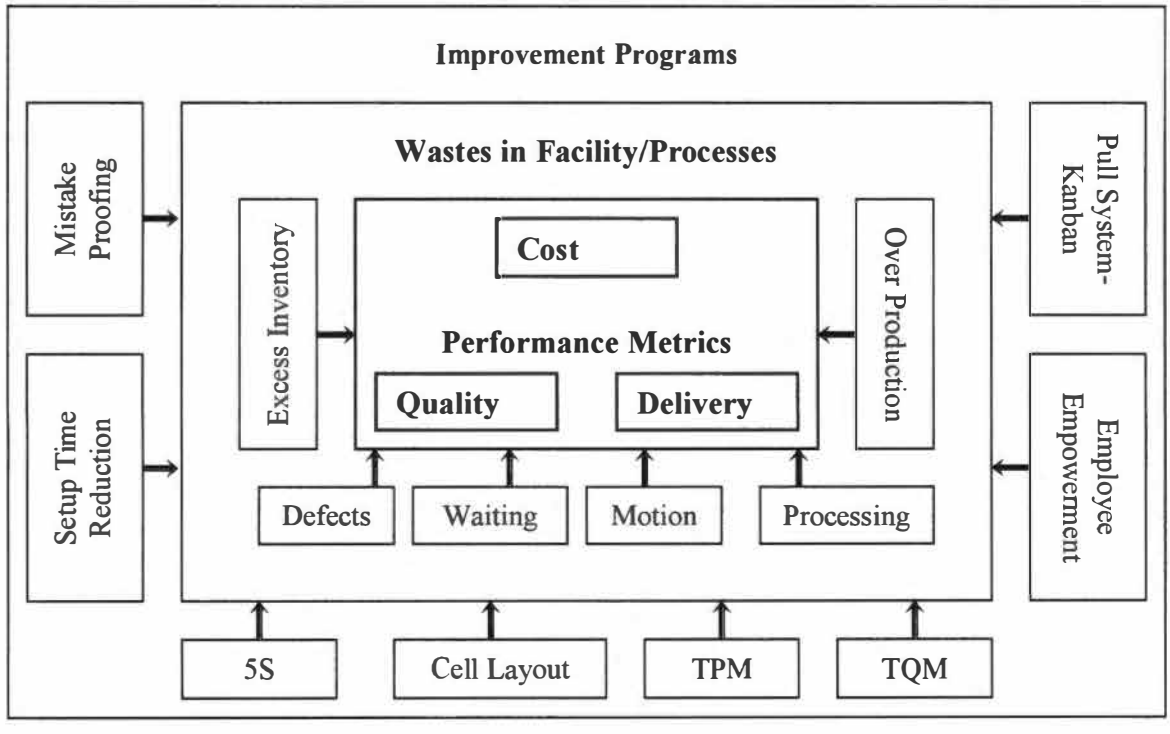


Figure 4: Continuous improvement program dynamics

A comprehensive continuous improvement program can control these wastages. Waste can be overcome or eliminated by using the tools and techniques of Lean Manufacturing.

These techniques include:

- Pull systems
- Cells
- Employee empowerment
- Setup time reduction
- 5S
- Mistake proofing

Several items differentiate traditional production from Lean. Table 1 [35] identifies the key organizational characteristics in a Lean organization and a traditional manufacturing organization. The chart identifies the main differences between these two systems. The table is adapted from the book The Machine That Changed The World, by Womack James P., Daniel T. Jones, and Daniel Roos 1990.

2.2 Define Employee Stress

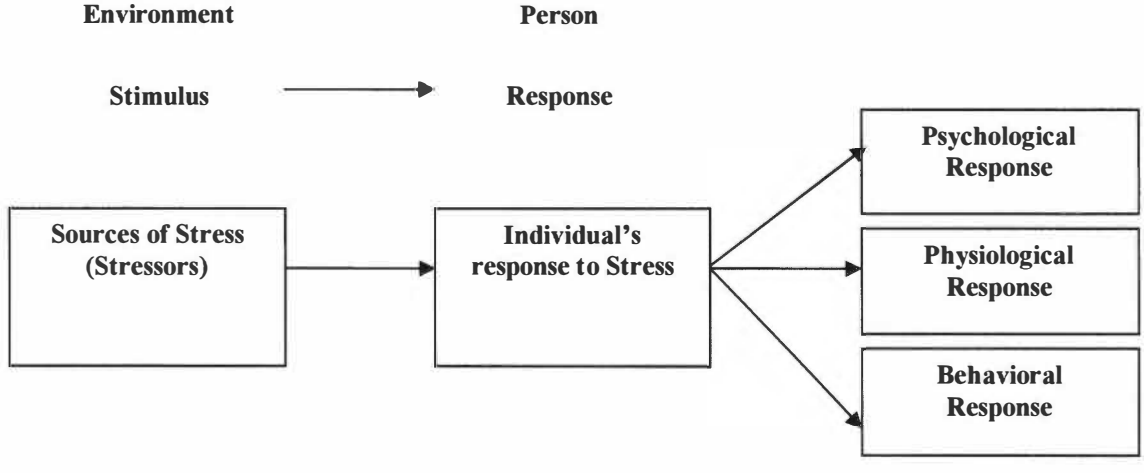
Stress is defined as any influence that disturbs the natural equilibrium of the body and includes within its reference physical injury, exposure, and deprivation of all kinds and emotional disturbance [4, 5]. Stress in controlled proportions acts as a stimulus [4] and can make employees more alert resulting in improved performance. However, too much stress can be

Table 1: Organizational characteristics of traditional production and Lean

Organizational Characteristics	Traditional Production	Lean Manufacturing Production
Organization	Vertical organizational structures that restrict smooth flow of vital information	Horizontal structures that encourage and initiate vital flow of information
Leadership Style	Executive command with lack of farsightedness	Visionary leadership with individual participation
Business Strategy	Strategy based on exploiting economies of scale	Customer focused based on exploiting competitive advantage
Culture	Loyalty and obedience with subculture of alienation and labor	Harmonious culture of involvement based on long-term development of human resources
External Relations	Based on profits	Based on long-term relations
Information Management	Based on weak abstract reports	Management based on visual control systems maintained by all employees
Customer Satisfaction	Lower customer satisfaction but higher customer satisfaction can be achieved by sacrificing other performances	Customer is always put first and kept happy; this is achieved by efficient use of resources
Production	Large single purpose machines with minimal flexibility and massive inventories	Ergonomically designed and high flexibility machines with minimal use of inventories
Engineering	Minimal input from customer during designing of product and no consideration for production difficulties	Design based on input from customer requirements and concurrent development of product
Maintenance	No preventive maintenance; use of highly skilled workers for maintenance	Preventive maintenance; each operator responsible for maintenance and first contact for maintenance
Production schedule	Based on forecasts	Based on customer demand
Production cycle	Weeks/months	Hours/days
Lot size	Large with consistent batch size	Small and usually one piece flow
Plant layout	Based on department function	Cells or lines based on product families
Quality assurance	Use of lot sampling techniques	100% accomplished by each operator at each operation
Worker empowerment	None or very low; no decision making responsibilities	High and often quick decision making responsibilities encouraged to generate ideas
Worker assignment	One person / machine	One person responsible for many machines
Inventory	High to balance demand fluctuations	Low, small amounts between operations (use of super markets)
Cross training	Non-existent	Highly implemented

Figure 5 shows how stressors stimulate a person to respond. There are several factors in the manufacturing sector that are a source of employee stress including but not limited to change. In a stressful environment employee responses are as follows:

- **Psychological Response**: 12% of employees have called in sick because of job stress, 3% of employees are absent everyday.
- **Physiological Response**: 62% of employees routinely find that they end the day with work-related neck pain, 44% of employees report stressed-out eyes, 30% of employees suffer from back pain' 17% of employees have muscular pain' and 38% of employees complain of hurting hands.
- **Behavioral Response**: 40% job turnovers are due to stress, 34% of employees report difficulty in sleeping because they were too stressed-out.



Source: Reproduced and Adapted from *Understanding Stress*, Sutherland and Cooper, 1990, Nelson Thornes Ltd.

Figure 5: Model indicating individual response to stress

2.3 Review of Past Research

There are deferring views amongst researchers of the impact Lean has on employee stress. For example, an employer's frantic movement towards Lean implementation may increase workers resistance to change [3]. Fullerton Rosemary suggests that Lean can backfire if not implemented carefully [9]. Psychologists question whether Lean's purported benefits take into account the higher stress levels and physical fatigue that may result as workers struggle to keep up with the changes [9]. Certain manifestations of employee stress are mental distress, social instability, and physical illness. The physical and mental well being of employees are important to the well being of the organization [13, 15]. "There's a big debate between researchers who think Lean will help people work smarter and people who think it will make workers miserable..." said Sharon K. Parker, PhD, of the University of Sheffield. Parker and Slaughter have used the term "management stress" to characterize a system in which workers are subjected to relentless pressure from the pace of work, the absence of buffers and relief workers, managers, and their own team members [18].

While, Lean as a methodology has the potential to significantly improve productivity and quality, it may contribute to stress in employees. This is a major concern, since workers play an important role in the operation and continuous improvement of an organization [7]. The negative impact caused by employee stress makes it incumbent upon managers to design a system that while being competitive does not induce excessive stress [6]. As fast paced and innovative systems are introduced in industry to keep companies competitive questions are raised as to the impact of these systems on employee stress.

Individualized wage systems enable management to reward effective workers and penalize ineffective ones, [3,6]. Effective implementation of work systems such as a Lean Manufacturing system or Toyota Production System (TPS), TQM, Re-engineering, Modular or Cellular Manufacturing, Agile Manufacturing, will help in finding alternatives that promote healthy work environments which reduce job stress and related employee problems [11].

TPS management is steadfastly portrayed not only as humane and efficient but also as a necessary model for restoring industrial competitiveness in the automotive industry [21]. David Meier in his article "The Reality of Lean Manufacturing" said, "In reality very few of the principles of Lean Manufacturing will make sense to our rational mind for one reason: Lean will create urgency, stress, and discomfort". Our normal human tendency is to seek comfort and calm safety and security [15]. Urgency, stress and discomfort represent danger and invoke our "fight or flight" mechanism of survival [16]. The problem is that we do not understand the fundamental philosophy of Lean. The basis of Lean implementation is to minimize waste and respond to our customers needs.

Responding immediately to customer needs will create urgency, stress, and discomfort if the system is not reliable [28]. Perhaps one of the most overlooked aspects of Lean is that if properly applied, it will drive 'urgency' to correct problems rather than gloss over them. Additionally, Lean methods will make shortcomings in the system surface quickly thus giving manager's ample time to correct them. [7]. Other benefits will include but will not be limited to the following:

- Problems will surface quickly and at times painfully
- A sense of urgency is automatically created regarding system reliability

- The weakest point of the system will be stressed to the point of breaking
- Operations will be forced to be close to the edge and as tight as possible
- Consistent rethinking and redevelopment of our practices

In summary, the objective of a Lean system is to force the need for continuous improvement. The challenge is to resist our normal human instinct to seek comfort rather than discomfort and the stress of a Lean system can be very uncomfortable. The key is to continually push beyond the comfort zone and drive continuous improvement to develop and strengthen system reliability. Japanese researchers have argued that the employee stress problem might reside in the very structure of a Lean system. They assert that this is due to the fact that a Lean system involves much more than just designing and producing the highest quality product or service. It actually focuses on reducing the cost of labor through the elimination of waste [22,23]. The essence of Lean is the improvement of productivity by the implementation of Total Quality Control (TQC), Quality Circles (QC), and other labor relation activities. [34].

Another possible source of increased employee stress may be Kaizen system. Kaizen is an umbrella concept covering many practices that are known worldwide. These concepts have developed strategies that assure continuous improvement involving people at all levels of the organization [23]. Kaizen, or continuous improvement, depends on workers contributions through programs such as suggestion programs and small group activities geared to problem solving. The goal is to support cost cutting, to accept job reductions, and to participate with management in changing work processes and practices [18,23]. Kaizen involves more than participation - it encourages workers to treat each other as suppliers, customers or competitors rather than as co-workers. It organizes

workers to adapt to many situations, to cooperate as a team, pay attention to details, to make the best use of human resources available, to share information with each other, to cooperate cross functionally, to build the system on existing technology, and to give continuous feedback to other workers [18].

In the distant past in the automotive industry, groups of assemblers worked together to assemble vehicle parts. To improve productivity corporations introduced certain Lean Manufacturing- techniques. Implemented in different parts of the plant at different times, these techniques included establishing a moving assembly line and organizing employees into work groups called 'cells' that were asked to standardize their procedures. Sharon K. Parker concluded that work groups induce lower employee stress than people working individually [3, 5].

Often times there are conflict between employer expectations and employee's perception of work roles and responsibilities. Roles that do not have clearly articulated expectations concerning behaviors or appropriate levels of performance are ambiguous ones [1]. Role conflict and ambiguity are significantly related to lower productivity as well as more tension, dissatisfaction, and work stress.

Job burnout could be a result of lower workplace social support and poor health [1]. The results of the relationship between social support work stress and negative stress outcomes remain undefined. Various results have been found depending on the source, amount, type of support, and the personality of the employee. The directionality of these relationships has not been established in a Lean Manufacturing environment.

Mental and physical health of employees is the key to success in a Lean environment. Immuno suppression, muscular tension, and physical exhaustion are results of the body's

repeated and ineffective attempts to cope with stress [2]. Monotonous and/or repetitive jobs can lead to boredom, resulting in increased stress levels. While TPS empowers employees with decision-making responsibilities it can be a source of job strain and the risk mental fatigue.

Some case studies suggest that Lean Manufacturing creates an intensified work pace and work demand with no increase in decision making authority or employee skill levels. Such work can be considered to cause high job stress. Fast-paced, repetitive, short-cycle work with few rest breaks, long work hours, and low worker authority are risk factors not only for job related injuries but also may be a warning sign of chronic job stress. The stress could be a factor in illnesses with longer latencies such as hypertension and heart disease.

For many workers career development is an important issue. Proper training is an integral part of career development for most workers [1]. Older employees tend to be stressed and anxious about redundancy, demotion, obsolescence, lack of job security, and forced early retirement [1]. The 1990 text from MIT that had assessed Lean Manufacturing in auto manufacturing, "The Machine that Changed the World" [35], argued that, in the best Japanese auto companies, "multi skilled" workers could solve quality problems at their source and boost productivity. The freedom to control one's work replaces the mind numbing stress of mass production. Armed with the skills they need to control their environment, workers in a Lean Manufacturing plant have the opportunity to think actively, indeed proactively, to solve workplace problems. Lean Manufacturing production does seem to provide more job enhancement, cross-training, and problem-solving opportunities than traditional manufacturing jobs. However, quality

circles should not be mistaken for autonomous work teams nor are they empowered to make managerial decisions. Interpersonal relationships are one of the main causes of stress in both large and small companies. Research shows various causes for different behaviors in employees are due to abrasive personalities, peer pressure, leadership style, social density, and social incongruence [1]. Relationships between co-workers, and/or superiors can be negative due to rivalry, competition, and office politics. However, social support in the form of stress management groups can be helpful in reducing stress. Also, sharing of issues or other workplace problems can help significantly reduce employee stress.

Researchers have come to the following conclusions relative to the impact of change on employee behavior:

- Employees profess satisfaction with their participation in planning production. However, once the plan is in operation, they feel betrayed by the speed-up and lack of participation [18].
- Operators that are kept active, without being rushed, are less bored and more alert than those who are not and are less likely to be injured on the job are [16].
- Management's unwillingness to waste employee's time signals employees of their value and enhances their morale [24].
- Management programs to boost employee morale have shown significant improvement in productivity. This shows managements concern for employees, for example by promoting employee education in both work-related and personal matters. However, activities that are not directly related to the work have at best a temporary effect and add cost to operations [18]. This encourages employees in

participating in future programs and reinforces that management is working for the betterment of its employees.

- Management programs to reduce waste will improve employee morale and upgrade measurements of performance. [18].
- Productivity improvements cannot result in layoffs of employees.
- Production supervisors find that their involvement in and ownership of improvement projects is incompatible with spending their time checking attendance or expediting manufacturing. Under Lean Manufacturing technical changes on the shop floor have the potential to drive changes in the support and management structure.

One of the contributions of this study is to investigate past research linking Lean to employee stress. Literature search has revealed that there is no single scientific study that has specifically linked employee stress to Lean. However, there are components of information that exist in different publications, journals, books, graduate and doctoral dissertations that suggest that such a link does exist. This chapter does list technical aspects and human aspects that can contribute to employee stress. This leads to the hypothesis, proposed in chapter 1, that the progression of Lean implementation through it's various phases' leads to the increase of stress levels in employees.

The following hypothesis is proposed

H_0 = Lean implementation increases employee stress

H_A = Lean implementation does not increase employee stress

Chapter Three

Research Methodology

Chapter three discusses the methodological approach utilized for conducting this study. The methodology is developed to fulfill the contribution of this study that is based on the hypothesis that the progression of Lean through it's various phases leads to the increase of stress levels in employees. Investigation of research provided an insight into the various technical aspects and human aspects of Lean that need to be incorporated in the research methodology. The research methodology includes approach of data gathering, design of survey instruments, validation of survey instruments, data collection, and data analysis methods used for the study.

3.1 Approaches to Data Gathering

The principal approach of data collection for this particular study is a survey instrument (or self-reporting method). Surveys have a low response rate, are time consuming, and it is very critical that people administering the survey are trained in conducting the surveys. Surveys or self-reporting methods are low-cost and effective because they allow employees to report and register specific scenarios and instances during which they may have experienced psychological and physiological thoughts. There is an aspect of added reliability and accuracy when an event is reported and registered by the individual who experienced the psychological and/or physiological thoughts. Additionally, situations are easily recognized by the employee and involve aspects of the job that decreases the employee's chances of performing the job to personal or organizational standards. Since the focus of this study is to understand how

lean implementation influence employee stress, self-reporting method is the only feasible approach that can provide a general framework for the study.

3.2 Survey Instrument Development

For the acceptance or rejection of the hypothesis it is necessary to measure the Lean activities in an organization and the employee stress in that organization. This information will help to understand the relationship between implementation of Lean and employee stress. For this a survey instrument (questionnaire) is designed. The survey instrument contains two questionnaires:

- The Lean Environment Evaluation Profile (LEEP) (see appendix for details)
- The Work Stress Profile (WSP) (see appendix for details)

3.2.1 Lean Environment Evaluation Profile (LEEP)

LEEP is designed to assess the perception of the employee about the degree of Lean implementation in the organization. The LEEP exclusively measures the key lean implementation tools for that particular organization. LEEP quantifies the extent to which each facility has become a Lean producer. For the purpose of this study Lean transition is categorized into three phases as discussed in chapter 1. The LEEP identifies the key Lean techniques and tools that help categorize an organization into the three Lean phases, which are Lean Introduction Phase, Lean Implementation Phase, and Lean Refinement Phase. Table 2 lists the contents of the LEEP questionnaire. For the purpose of this study an organization is said to be implementing Lean principles and tools based on the following categories manufacturing flow, employee empowerment, employee involvement, workplace organization, visual control, material movement, quality, customer delivery, Lean culture.

Table 2: Impact of Lean principles in various phases of Lean

NO.	LEEP Question	Lean Introduction Phase	Lean Implementation Phase	Lean Refinement Phase
1	Plant layout helps reduce travel time	×	×	
2	Layout in the form of distinguishable cells		×	×
3	Signaling system to improve product flow	×	×	×
4	Small lot size production		×	×
5	Product mix to produce variety of products			×
6	Operators responsible for more than one machine	×		
7	Operators have additional responsibilities other than operating machines	×	×	×
8	Work groups and teams mode of operation	×	×	
9	Supervisor more as a facilitator than supervising		×	
10	Operators have control over production flow			×
11	Visual control used to increase effectiveness of communication	×		
12	Compensation based on individual contribution towards the overall performance		×	×
13	Company culture allows operators to make decision for quick problem solving		×	
14	Company has focus on quality		×	×
15	Company has focus on customer delivery		×	×
	Total	6	4	5

From table 2 the total technical or human aspects having a major impact in that particular phase are; 6 aspects in Lean Introduction Phase, 4 aspects in Lean Implementation Phase, 5 aspects in Lean Refinement Phase.

The scoring system of LEEP is designed to help categorize organizations into the three Lean phases. The following are scoring details for LEEP: Each question is measured on a scale of 1 to 10, 1 is the lowest possible score for an individual question and 10 is the maximum score for an individual question

Multiplying 6 aspects with maximum score of 10 will give us a score of 60. This is the maximum score for Lean Introduction Phase. Hence maximum score for Lean Implementation Phase is 40 and 50 for Lean Refinement Phase. The three phases of Lean Manufacturing implementation are:

Lean Introduction Phase: This is the most primary phase of Lean Manufacturing Implementation. In this phase employees and managers alike are not completely aware of the Lean Manufacturing concepts. This is the phase when the organization or individuals are involved in educating themselves with Lean Manufacturing.

Lean Implementation Phase: This is a phase where organizations and individuals are somewhat educated and aware about Lean Manufacturing. This is the phase when employees and managers alike have a strategy to implement Lean Manufacturing. The organization is implementing Lean Manufacturing tools and concepts in their day-to-day activities.

Lean Refinement Phase: This is the phase when employees and managers alike have implemented Lean Manufacturing concepts and tools. This is the phase when

managers and employees are refining, customizing, and honing the various lean implementations to improve their processes.

A scoring system is developed for LEEP based on the phases discussed above, which is shown in Table 3. A total score of 150 points can be scored on an individual LEEP questionnaire. If the total score is between 15 and 60 the organization is considered to be in lean introduction phase. If the total score is between 61 and 100 the organization is in the lean implementation phase. If the total score is between 101 and 150 the organization is in lean refinement phase.

This score stratification is based on literature research and interviews with experts; however, it is not based on any specific scientific analysis. This scoring system is not based on any statistical analysis.

Table 3: Different phases of Lean transition and score stratification on LEEP

Lean Phase	**Score Group**
Lean Introduction Phase - This phase indicates that some in the organization are aware of lean production principles, but there is not an orchestrated effort to implement it.	0-60
Lean Implementation Phase - In this phase a formal implementation strategy has been established. Employees start implementing lean techniques and tools in their day to day activities.	61-100
Lean Refinement Phase- In this phase employees are refining, customizing, and honing the various lean implementations to improve their processes.	101-150

3.2.2 Work Stress Profile (WSP)

The WSP is used to measure the stress levels in employees in an organization. The WSP exclusively measures workplace related stress. The WSP (see appendix) was adapted from a survey designed by Phillip L. Rice which is published in the book "Stress and Health" [36].

The following three levels of stress are measured:

1. Stress due to interpersonal relationships at work
2. Stress due to physical activities at work
3. Stress due to job satisfaction or interest

The questionnaire has fifty-seven questions of which several questions are repeated in verbatim. Several questions within the WSP check the consistency of the subject in answering the questions. Table 4 provides the scoring scale for the WSP. A minimum score of 1 and maximum score of 5 can be scored on every question of the WSP. A total score of 285 points can be score on the WSP. If an individuals score is greater than 141 it indicates that the individual has high stress. A score between 111 and 140 indicates that the individual has normal score.

Table 4: Scoring scale for WSP

Categories	**Scoring**
High Stress	> 141
Normal Stress	141-111
Low Stress	< 111

And if the score is below 110 the individual has low stress. This scoring scale was discussed by Phillip L. Rice which is published in the book "Stress and Health" [36].

3.2.3 Testing Survey Validity

The two surveys were checked for validity and biases. Members of The College of Engineering and the Statistics department in the Business School validated the LEEP. The assistance of Professors at the University of Tennessee (UT) Industrial Engineering Department and a Professor of the UT Statistics Department who approved the lean questionnaire (LEEP) and verified the statistical design to eliminate or reduce biases. A reliability test was conducted on the lean questionnaire-using minitab a statistical software program. The widely used Cronbach's alpha was used as a measure for reliability. The reliability of the lean questionnaire was calculated to be 0.83.

For validity the face validity was conducted so as to verify that the lean questionnaire reflects the content of the concept of lean. However, no other validity test was done either on the lean questionnaire or the stress questionnaire.

The following steps were taken to reduce or eliminate biases in the surveys:

- Biases arising from the interviewer were controlled by proper training of the person in charge of conducting the survey
- Biases due to failure to understand the questions were eliminated by using simple language and simple statements that capture the opinion of the employee replying to the questionnaires
- Repeating questions 1, 3, 4, 12, 22, 23, and 24 with 40, 41, 42, 53, 45, 47, and 48 (descriptive statistics shown in chapter 4) eliminated biases due to errors in response whether voluntary or involuntary. All questionnaires that had different responses to

these questions were discarded. However this test wasn't applied to the two pilot tests conducted prior to the main research.

3.3 Data Collection

3.3.1 Pilot Test

Before the survey instrument was used to collect data for hypothesis testing, it was tested within an organization (the name of this organization is not released as per the wish of the organization). There was no knowledge about the lean activities of the organization in which the pilot test was conducted nor was there any knowledge about the lean programs conducted in the past in that organization. Two tests were conducted at an interval of 8 days. However there was no assurance that the samples collected from both these pilot tests were from the same group of employees. Samples of 22 questionnaires were collected form the organization. The same test was conducted after eight days in the same organization and a second set of readings was obtained. The main intent of having two pilot tests was to check for the consistency of the samples. However, since there was no assurance that the samples were collected from the same group of employees it cannot be proved that there is consistency between the two tests. Prior to calculating the sample size a pilot test was conducted to measure the sample size. Table 5 shows the Pilot Test Results. The descriptive statistics was calculated using the mintab software. The descriptive statistics from both the pilot tests shows that the mean of the stress is 157.18 (from first pilot test) and 153.89 (from second pilot test).

Table 5: Pilot test results

	Pilot Test 1		Pilot Test 2	
Variable	**Lean (LEEP)**	**Stress (WSP)**	**Lean (LEEP)**	**Stress (WSP)**
N	22	22	22	22
Mean	89.05	157.18	82.68	153.89
Median	89.50	156.00	83.50	152.00
TrMean	89.75	156.30	83.45	152.20
Std. Dev.	14.60	13.06	14.48	15.42
SE	3.11	2.78	3.09	3.29
Mini.	51.00	141.00	44.00	123.00
Max.	113.00	191.00	106.00	191.00
Q1	78.75	147.25	77.25	144.00
Q3	101.00	163.50	91.00	159.00
Pearson Correlation of Lean and Stress	-0.463		-0.275	
P-Value	0.030		0.0215	

This indicates that the employees are stressed above normal. This is true because a score of 140 and below on the WSP questionnaire indicates normal stress (see table 3). From both the pilot tests the minimum stress was 123.00 this indicates that no employee had a lower stress, as scores 110 and below on WSP questionnaire is lower stress (see table 3). The minimum and maximum score for lean from LEEP in both pilot tests indicates that the organization is in lean introduction or lean implementation phase. This conclusion can be made by a confidence level of $p=0.03$ from first pilot test and $p=0.021$ from second pilot test. The correlation between LEEP and WSP indicates that as the lean implementation increases within an organization the employee stress decreases. This is indicated by a correlation of -0.463 and -0.275 from pilot test 1 and pilot test 2 respectively.

3.3.2 Conducting the Survey

The industrial setting of this study offers an opportunity to examine the effects of work pressure in organizations with various degrees of lean implementation. Ten facilities that were contacted were interested in the study. All of the ten facilities are in eastern United States. Five facilities in Knoxville, Tennessee, three facilities in Huntsville, Alabama, one in Nashville, Tennessee, one in Maryland, Pennsylvania and one in Houston, Texas. The size of the facilities varied from 200 to 500 employees. They were for the most part production workers with varying skills. The data was collected over a period of eight months.

The instrument of measurement was same in all the facilities. The questionnaire was filled out during work hours. The surveys were hand delivered to the Human Resource Manager or assistant who was trained to conduct the survey. The completed surveys were

later collected from the HR manager. As a result there was no direct contact between the subjects and the researchers. Both questionnaires were attached together so as to make sure that an individual answered both the surveys. The questionnaires were self-explanatory and took from 12 to 15 minutes to complete. As soon as the data for the research (and not the pilot study) was collected from the subject, the following steps were taken to prepare the data for analysis. The responses were checked to see if they are legible/ readable. All questionnaires that were not distinct in their responses were discarded. The descriptive statistics of the responses received that were discarded due to various biases is discussed in the first paragraph of chapter 4.

3.3.3 Sample Size

The results from pilot study were used to calculate the sample size (n) using the following formula:

$$n = \frac{\sigma^2 Z^2_{1-\alpha/2}}{d^2}$$

$Z_{1-\alpha/2} =$ The critical value, the positive z value that is at the vertical boundary for the area of $\alpha/2$ in the right tail of the standard normal distribution (1.96)

σ = The population standard deviation (13.06)

d = desired precision or maximum error (3)

For calculating the sample size the standard deviation for the population was estimated from pilot test 1 and pilot test 2 shown in Table 5. The desired precision or maximum error was set at 3. An acceptable confidence level of 95% is adopted for this study. The mean standard deviation and correlation for each item in the tools were

measured and calculated using Minitab. For an alpha of 0.05 and desired precision or maximum error of 3 the given sample size was calculated to be 72.80 rounded up to 73.

3.4 Data Analysis

3.4.1 Hypothesis Testing

An essential requirement for statistical inference type of research is setting up and testing hypothesis. For the purpose of this study it is hypothesized that:

H_0 = Lean implementation increases employee stress

The outcome of a hypothesis test is 'reject H_0' or 'do not reject H_0'.The probability value (p-value) of a statistical hypothesis test is the probability of getting a value of the test statistic. It is the probability of wrongly rejecting the null hypothesis if it is in fact true. The p-value if smaller the result is significant. That is, if the null hypothesis were to be rejected at $\alpha = 0.05$, this would be reported as '$p < 0.05$'. Small p-values suggest that the null hypothesis is unlikely to be true. The smaller it is, the more convincing is the rejection of the null hypothesis. It indicates the strength of evidence for say, rejecting the null hypothesis H_0, rather than simply concluding 'reject H_0' or 'do not reject H_0'.

A two-sided test of significance is adopted for testing the hypothesis. This indicates that nothing specific can be said about the average employee stress, only that, if we could reject the null hypothesis in our test, we would know that the average employee stress is likely to be less than or more than normal stress.

3.4.2 Correlation Analysis

Correlation analysis is the statistical tool used to describe the degree to which lean manufacturing implementation is linearly related to employee stress. The Pearson product moment coefficient of correlation, or simply, the coefficient of correlation, r is a measure

of the strength of the linear relationship between the two variables; lean manufacturing implementation and employee stress. A value of r near or equal to 0 implies little or no linear relationship between lean manufacturing implementation and employee stress. The closer r is to 1 or to –1, the stronger the linear relationship between lean manufacturing implementation and employee stress.

3.4.3 Regression Analysis

In the linear regression model, the dependent variable; employee stress, is a linear function of independent variable; lean manufacturing implementation plus an error introduced to account for all other factors. A linear regression model is used as both the dependent variable and the independent variable are quantitative measures. The following regression model is used to obtain the regression equation.

$$y = \beta_0 + \beta_1 x$$

Where y = Employee stress β_1 = Slope intercept

x = Lean implementation β_0 = Intercept parameter

In the above regression equation, y is the dependent variable; employee stress. x is the independent variable; lean manufacturing implementation. The goal of this regression analysis is to obtain estimates of the dependent and independent variables which indicate how a change in the independent variable; lean manufacturing implementation affects the values on dependent variable; employee stress.

The regression analysis is based on the following assumptions. The assumptions of linearity, independence and constant variance can all be checked using a plot of residuals against fitted values. If all the assumptions hold then this plot should show a random

scatter. The assumption of Normality is checked using either a histogram or Normal probability plot of the residuals. If the errors follow a Normal distribution then the histogram of residuals should be roughly bell-shaped, whereas the Normal probability plot should approximate to a straight line. If the sample size is small it is very difficult to tell whether the distribution is Normal or not.

3.4.4 Descriptive Statistics and Graphical Analysis

Descriptive statistics was used to describe the basic statistics of the data in the study. It provides in detail graphical analysis, they form the basis of virtually every quantitative analysis of the data. Descriptive statistics can conclude what the data shows. Descriptive Statistics is used to present quantitative descriptions in a manageable form. Descriptive statistics helped to simplify large amounts of data in a sensible way. Descriptive statistic reduced lots of data into a simpler summary. Descriptive statistics made the analysis of various measures easy to understand. Graphical analysis is extensively useful in comparing the results and gives a quick understanding of the results. Graphs and tables are a quick and easy to understand.

Chapter Four

Research Findings and Discussion

In this chapter the contributions of this study are discussed using various statistical tools like correlation analysis, regression analysis. Hypothesis testing is used to approve the hypothesis (H_0) that Lean implementation increases employee stress. Various Lean principles that impact stress are discussed and the level of stress in various phases of Lean is analyzed.

4.1 Descriptive Statistics

Table 6 provides statistics regarding questionnaire distribution and response. The table provides the total number of questionnaires distributed, returned, and qualified for analysis. Inconsistencies in answers were determined by identifying difference in response to similar questions. There was a total of 30.62% response rate for the questionnaires.

Table 6: Questionnaire response statistics

Description	Number of Questionnaires	Percentage of Total Questionnaires
Questionnaires distributed	1300	100%
Questionnaires returned	398	30.62%
Questionnaires rejected	49	12.31%
Questionnaires rejected due to missing data	28	7.04%
Questionnaires rejected due to inconsistency in data	21	5.28%
Total Questionnaires distributed that were used for analysis	349	26.84%

This relatively high response rate can be attributed to the organization enthusiasm about the results and outcome of this research.

The 12.31% rejection rate for the questionnaires returned constitutes mainly due to missing data and inconsistency in the answering of the questionnaires. The rejection rate due to missing data is slightly higher than the inconsistency due to answering due to the fact that some employees were not aware of the lean initiatives of the organization that lead to their not answering the questionnaire completely. See appendix for information that provides further detailed descriptive statistics regarding questionnaires discarded due to inconsistency in answers.

Table 7 provides the descriptive statistics for the data collected. A total of 349 samples were analyzed. The mean lean (LEEP) score is 86.57, which indicates that an employee is in the lean implementation phase. The mean of the stress score is 155.71; this indicates that on an average the stress in employees is above normal because as indicated in Table 3 a score greater than 141 represents above normal stress levels. Also, it is interesting to observe that the minimum stress score is 131, which is normal stress. This indicates even though the lean transition could be in the refinement phase the stress will not be lower. The standard deviation for lean and stress are 16.3 and 12.1 respectively.

4.2 Relationship between Employee Stress and Lean

The main contribution of this study is to find the relationship between employee stress and Lean. Different statistical tools are used to find this relationship. Predominately correlation analysis and regression analyses are used to understand the relation between employee stress and Lean. Hypothesis testing is used to approve the null hypothesis.

Table 7: Descriptive statistics of the samples collected

Variable	Lean	Stress
N	349	349
Mean	86.576	155.71
Median	88.000	155.00
TrMean	87.003	155.85
Std. Dev.	16.305	12.16
SE	0.873	0.65
Mini.	41.000	131.00
Max.	122.000	182.00
Q1	78.000	147.00
Q3	97.000	166.00

4.2.1 Correlation Analysis

As discussed the correlation coefficient r, quantifies the direction and magnitude of correlation. A linear correlation analysis is used to measure the linear association between Lean and employee stress. The correlation coefficient shows there is a negative correlation between employee stress and Lean. This negative correlation coefficient (-0.531) indicates that there is a statistically significant ($p < 0.001$) linear relationship between these two variables such that the more an organization implements lean manufacturing, the lower employee stress gets. This suggests that as one of the variables increases there is a tendency for the other variable to decrease.

The coefficient of determination (r^2) is calculated to be 0.28. Coefficient of determination shows the fraction of variance between Lean implementation and

employee stress. That is 28% of the variation is shared between Lean implementation and employee stress.

4.2.2 Regression Analysis

Regression analysis is conducted to measure the relationship between Lean and employee stress. By explicitly incorporating the data of the stress variable into the statistical analysis it is possible to assess the nature of the relationship between lean implementation phase and employee stress. The following regression model is used to obtain the regression equation.

$$y = \beta_0 + \beta_1 x$$

Where y = Employee stress β_1 = Slope intercept

x = Lean implementation β_0 = Intercept parameter

The regression equation obtained using Minitab is given below.

$$y = 190 - 0.396x$$

That is,

Employee stress = 190 – (0.396) x (Lean)

[Employee stress is measured using WSP (maximum score is 285, minimum score is 57) and lean implementation is measured using LEEP (maximum score is 150, minimum score is 15)]

The equation suggests that $\beta_1 < 0$ (- 0.396); so that the regression line slopes downwards which indicates that as lean manufacturing implementation increases, employee stress decreases. This is in support of the correlation coefficient -0.531 between lean manufacturing implementation and employee stress.

Table 8 shows the details of the regression analysis obtained using Minitab. From the regression analysis the standard error of the estimate about the regression line is calculated to be 10.31. The R^2-coefficient of determination-this indicates the percent of the variance in our dependent variable that is explained knowing the independent variable. It is the proportion of the total variability accounted for by the regression line is calculated to be 28.2% or 0.282 with ($p<0.001$). A p-value of 0.000 indicates that the probability of getting these results due to chance alone is less than 0.001; i.e., the association is probably not due to chance alone.

The t statistic is the coefficient divided by its standard error. The standard error is an estimate of the standard deviation of the coefficient, the amount it varies across cases. It can be thought of as a measure of the precision with which the regression coefficient is measured.

Table 8: Regression analysis

REGRESSION ANALYSIS					
Predictor	Coef	SE Coef.	T	P	
Constant	189.99	2.98	63.60	<0.001	
Lean	-0.3959	0.0339	-11.68	<0.001	
S = 10.31	R-Sq = 28.2%	R-Sq(adj) = 28.0%	PRESS = 37363.0	R-Sq(pred) = 27.34%	
ANALYSIS OF VARIANCE					
Source	DF	SS	MS	F	P
Regression	1	14505	14505	136.34	<0.001
Residual Error	348	36918	106		
Total	349	51424			

If a coefficient is large compared to its standard error, then it is probably different from 0. This explanation for t statistic is adapted from www.dss.princeton.edu

The analysis of variance describes the overall variance accounted for in the regression model. The *F* statistic represents a test of the null hypothesis.

It tests whether the R square proportion of variance F = 136.34 with a significance of $p < 0.001$. The F-test in the analysis of variance table tests the null hypothesis. The significant F statistic indicates that the null hypothesis is rejected and concludes that there is a statistically significant relationship between employee stress and lean manufacturing implementation. If the null hypothesis were true, then that would indicate that there is not a regression relationship between lean manufacturing implementation and employee stress.

But, instead, it appears that the lean manufacturing implementation and employee stress are correlated, as is indicated by a large *F* value and a small significance level.

Figure 6 shows the histogram of the residuals, which follows a bell shape curve. However, there are some missing data points in the histogram, shown in Figure 7. The normal probability plot of the residuals shows a straight line that indicates that it is reasonable that corresponding data points are observations from a normal distribution. However, there are some densely located data points at the center of the plot. Figure 8 shows the residuals versus the fitted values, which shows the data points to be a scattered balloon shape. However they are not funnel shape, which indicates they have a constant error variance. Figure 9 is a graph of the residuals versus the order of the data. This graph shows a negative slope because the data was sorted prior to obtaining the graph.

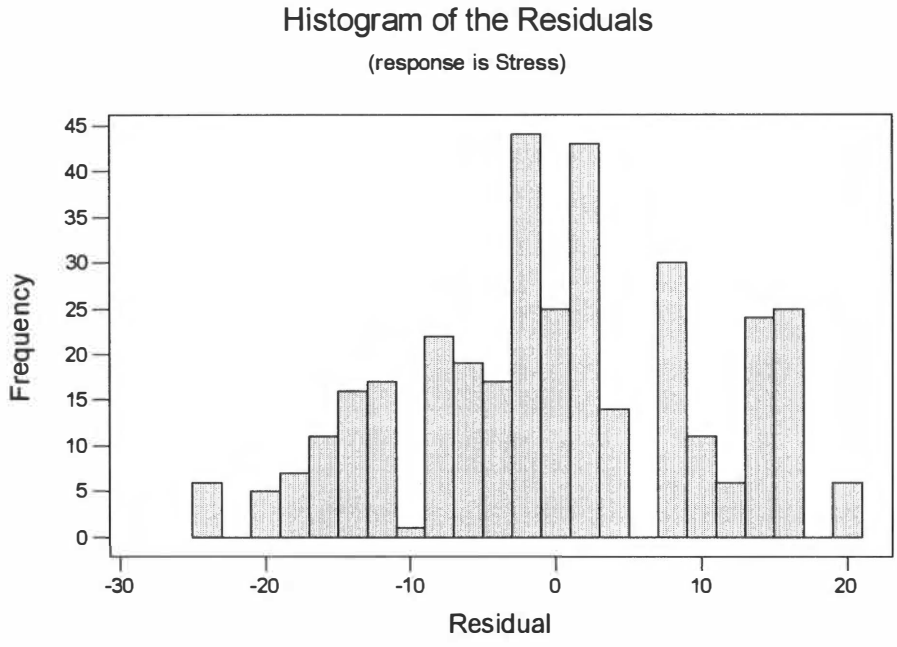


Figure 6: Histogram of the residuals

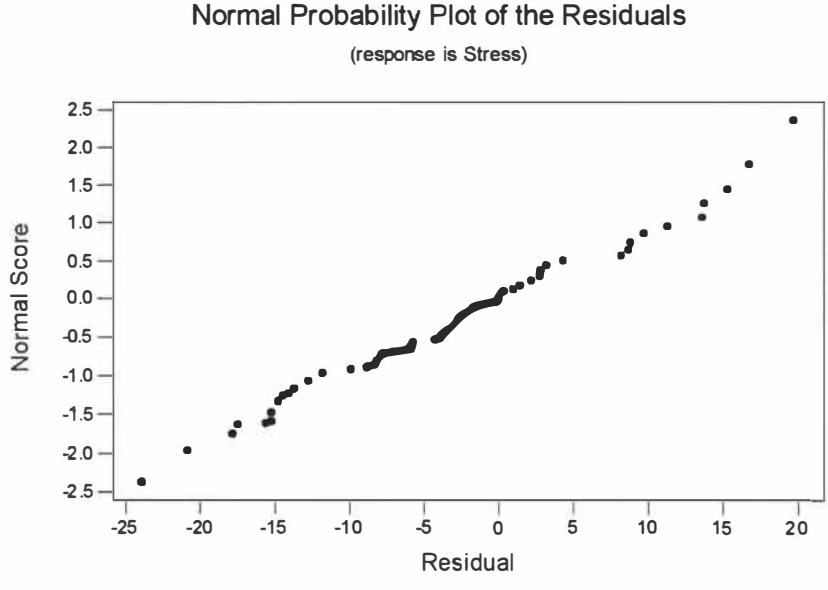


Figure 7: Normal probability plot of the residuals

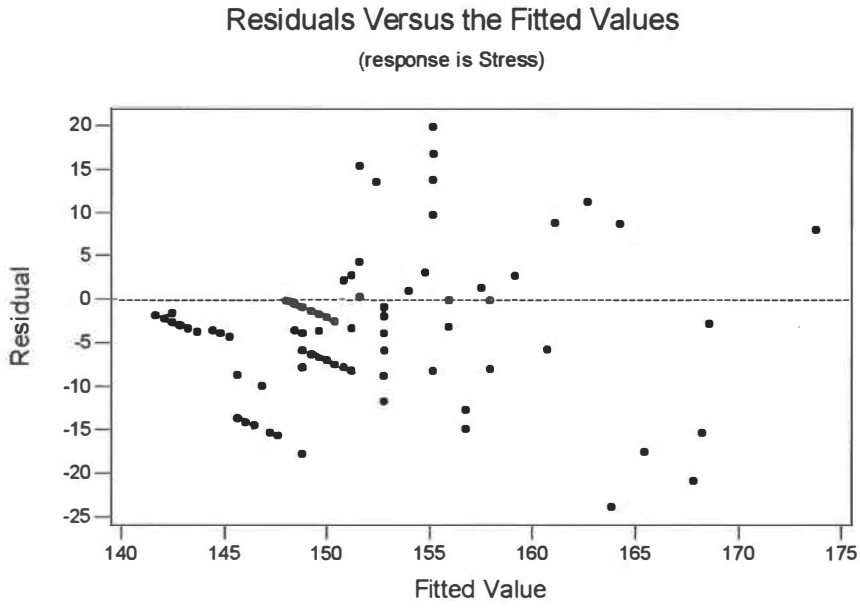


Figure 8: Residuals versus the fitted values

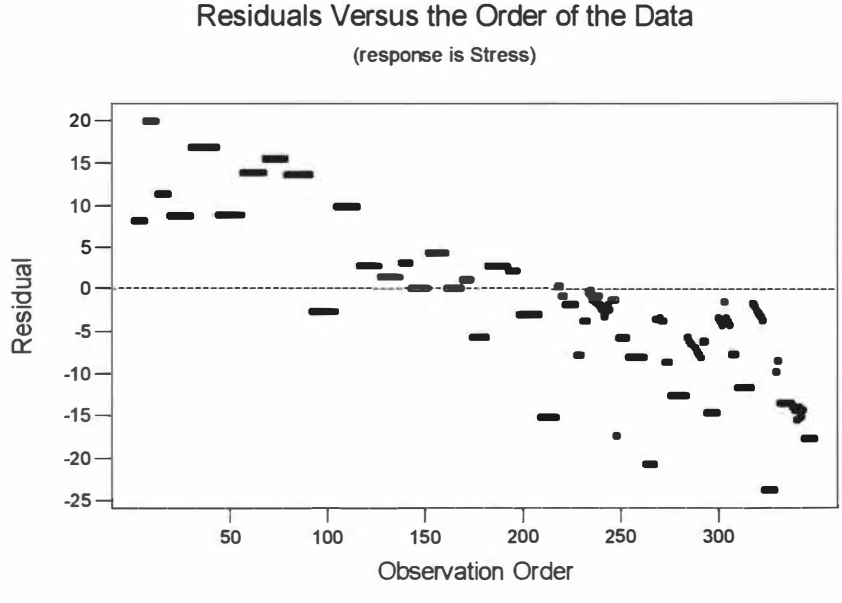


Figure 9: Residuals versus the order of the data

4.2.3 Hypothesis Testing

The following test will help us test the hypotheses and prove if there is any existence of relationship between lean implementation and employee stress.

It is hypothesized that the progression of Lean Manufacturing implementation through it's various phases' leads to the increase of stress levels in employees.

The following hypothesis is proposed

H_0 = Lean implementation increases employee stress

H_A = Lean implementation does not increase employee stress

The null hypothesis is to be tested using a two-sided hypothesis:

$H_0 : \beta_1 = b_1$ vs. $H_1 : \beta_1 \neq b_1$ for a fixed value b_1 of interest, are tested with t-statistic with n-2 degrees of freedom. The test rejects the null hypothesis if $|t| > t_{\alpha/2,n-2}$

$$t = \frac{\beta_1 - b_1}{\sqrt{\frac{\sigma^2}{S_{XX}}}},$$

Now, $b_1 = 0$ and n = 349 the t value is calculated using Minitab which is found to be t = -11.68. With d.f. = 347, the tabulated value of $t_{0.025,347} = 1.96$.

11.68 > 1.96 from the calculations. The observed value is highly significant at p-value < 0.001; hence H_0 is rejected, reflecting a significant reduction in employee stress with increase in lean implementation. Furthermore we can provide a confidence interval for the parameter β_1 using $\beta \pm t_{0.025,347} \frac{s}{S_x}$ From the equation we get (-0.3296, -0.4620). This means that we are 95% confident that by improving one unit of lean (that is one

score point on the LEEP) we will attain a mean reduction in employee stress between -0.3296 and -0.4620 (on the WSP).

Furthermore, F statistic will help us understand the relationship between lean and employee stress. The F statistic will compare the variance between explained factors and unexplained variance. The following formula is used to find the F statistics

$$F = \frac{MSR}{MSE}$$

As the F value from the F statistics is 136.34 ($p<0.001$), which is much greater than expected value of ($F_{1,347}$) 3.84. The computed F- distribution falls in the rejection region (for hypothesis testing $F < F_{1,n-2}$). Hence the null hypothesis is rejected and concludes that employee stress reduces as lean implementation increases. For this hypothesis the following criteria is applied.

$H_0 : \mu = \mu_0$ (accept H_0) $H_0 : \mu \neq \mu_0$ (reject H_0) This test is used to prove the hypothesis in different phases of lean implementation. This is a two-tailed test and significance level for the test is 0.05. The Work Stress Profile indicates that employee stress scores 141 and above is high stress.

Hence $\mu = 141$ After calculating the actual means for the information collected the μ_0 is calculated to be 155.71 with a standard deviation of 12.16.

$141 \neq 155.71$ Therefore $\mu \neq \mu_0$, $H_0 : \mu \neq \mu_0$, hence reject H_0, as sample data refutes the null hypothesis. After examining this result the sample data refutes the null hypothesis. Therefore we reject the null hypothesis.

4.3 Level of Employee Stress in Each Phase of Lean

There is a point in implementation of lean when stress levels amongst employees are at their peak. This is typically during the introduction phase of lean. Stress levels decrease as the organization progresses through the introductory phase. The beginning of each phase sees an increase in stress levels, with a gradual decrease towards the end of the phase. Table 9 provides details regarding employees stressed in each score category. These details help analyze the behavior of employees with regards to stress. The increase in stress is shown at points X and Y on Figure 10.

There are various explanations for these results. Employees inherently resist change due to human nature, and resistance levels depend on individual personalities. This resistance is a source of temporary increase in stress. As the lean phase progresses the employees accept the changes and these changes become a norm or a part of their culture leading to lower stress.

In addition, employees go through a learning curve when a new concept or tool is introduced. This is a primal source of temporary increase in stress as employees enter a new phase of lean. With time they become acquainted with the new concepts and tools thus causing their stress levels to drop with greater competence to the given tools and techniques.

Lastly, every employee has a different personality, consequently, the learning period and stress induced during the learning period can be different for every person. A quick look at Figure 10 and Table 9 shows that in the lean refinement phase the drop in stress levels in employees stabilizes considerably.

Table 9: Percentage of employees stressed in each score group

		Responses from LEEP		Responses from WSP	
Category	Score Group (points on LEEP)	Responses in each group (Persons)	Employees in Each Phase (%)	Responses in each group (Persons)	Employees Stressed (%)
Perception of Lean Introduction Phase	41-50	14	4%	14	100%
	51-60	30	9%	27	90%
Perception of Lean Implementation Phase	61-70	31	9%	24	79%
	71-80	31	9%	26	85%
	81-90	77	22%	58	76%
	91-100	84	24%	42	50%
Perception of Lean Refinement Phase	101-110	45	13%	27	60%
	111-120	21	6%	9	41%
	121-130	16	4%	6	36%

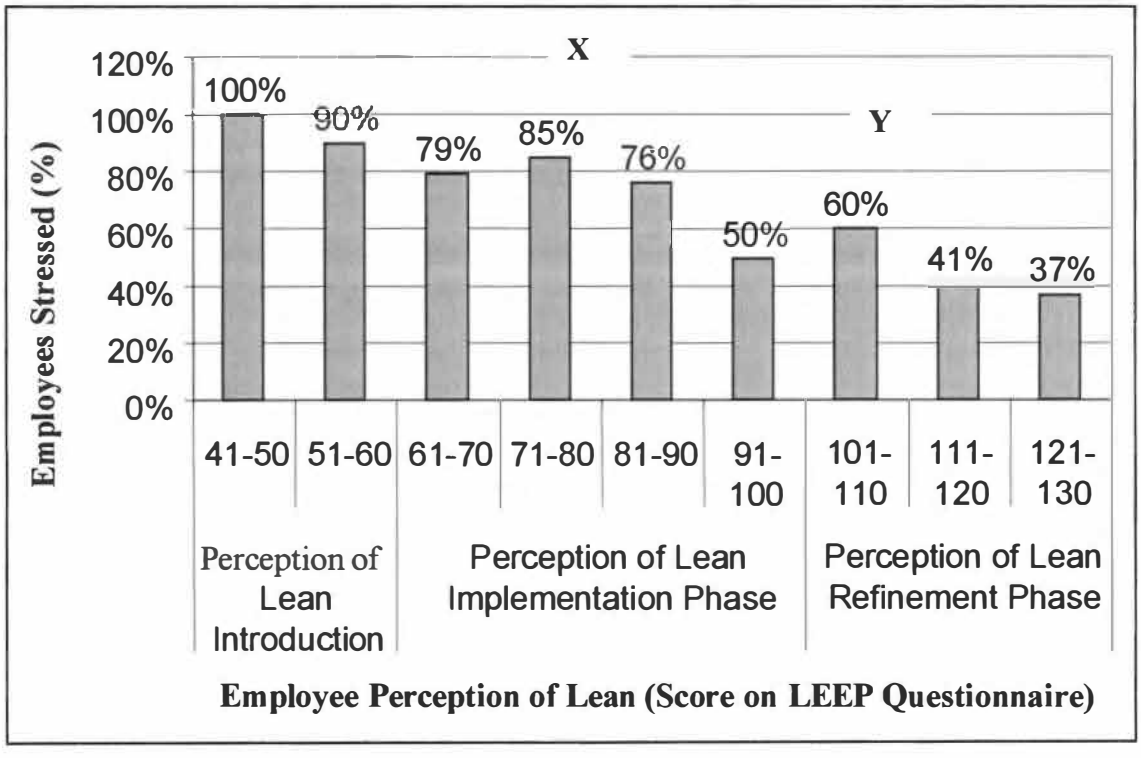


Figure 10: Relationship between employee stress and employee learning

4.4 Impact of Employee Stress on Lean Manufacturing Aspects

Each phase of lean manufacturing implementation has a different set of lean manufacturing aspects that significantly impacts employee stress. Lean manufacturing aspects are based on key lean principles. Lean is executed realistically in two different perspectives. These perspectives are: Lean Technical Aspects and Lean Human Aspects

4.4.1 Lean Technical Aspects

These includes the lean production issues and lean process capability issues (as shown by pillars of lean manufacturing in Figure 1). Table 10 shows the key Lean technical aspects that have a significant impact on the various phases of Lean implementation. The table contains the correlation for all the three phases of Lean implementation.

4.4.1.1 Physical Environment

5S is a lean principle which assists employees to keep their physical work environment orderly and organized. 5S consists of the following five S's:

1. Sort 2. Straighten 3. Shine 4. Standardize 5. Sustain

5S procedures should be implemented to sort, organize, standardize (clean-up), sustain, and train the workers with the present processes. 5S helps eliminate unnecessary material on the shop floor, while identifying areas for improvement. The correlation between 5S and employee stress indicates that during the lean introduction phase the 5S activities have a great impact on reducing stress.

Table 10: Technical issues faced during Lean transition

Question Numbers	Lean Technical Issues	Lean Introduction Phase*	Lean Implement Phase*	Lean Refinement Phase*
19	Physical environment crowded, dirty, noisy (5S)	0.38	0.25	0.16
20	Physical demands are unreasonable (Ergonomics)	0.25	0.43	0.33
1	Layout of the plant help in reducing travel time (Process Mapping)	0.14	-0.14	-0.07
2	Layout in the form of distinguishable cells (Cell formation)	-0.03	-0.14	-0.08
3	Use of signaling system to improve production flow (Kanban)	-0.17	-0.06	-0.09
11	Visual control used for effective communication (Visual Control)	-0.29	-0.09	0.13
4	Currently producing in smaller lot size (Achieve One Pc Flow)	0.41	0.19	0.27
5	Production system set so as to produce variety of products (Mix)	-0.13	-0.14	0.08
21	Quick response to production emergences (Line Stopping)	0.62	0.37	0.38
14	Company have focus on quality issues (Quality Program, SPC)	-0.38	-0.26	0.03
15	Company has focus on customer delivery (TPM, Setup Reduction)	-0.33	-0.16	-0.13
18	In service training is inadequate (Technical know how training)	0.36	0.45	0.35

*All values indicated in the table show the correlation between that particular question and employee stress

However, the correlation decreases as the 5S activities are implemented in lean implementation phase and lean refinement phase. A correlation of 0.38 (p=0.01) during lean introduction phase indicates that 5S has a very high correlation to stress in this phase. However, the correlation reduces to 0.16 in the lean refinement phase, which is substantially lower than the lean introduction phase. This indicates that 5S activities are very crucial to reducing stress during lean introduction phase. The success from 5S activities will boost the morale of the employees and encourage employees to take active participation in future implementations.

4.4.1.2 Ergonomic Design

As the physical demand is reduced from lean introduction phase to lean refinement phase the stress in employees is reduced. This is illustrated by a strong correlation between stress and physical demands during lean execution, which is very significant in reducing stress in lean refinement phase. This is indicated by a correlation of 0.43 and (p=0.003). The reason for such an impact during the lean refinement phase is due to mistake proofing (poka-yoke) of various operations that reduce the physical demand on employees. With mistake proofing of operations the physical demand of counter checking for quality on the employees reduces so does the stress caused due to it.

Mistake proofing also ensures that the operators do their job utilizing standard methods with ease and minimal mistakes. It also helps reduce the physical demand of lifting or moving tools and machinery to ensure that the mistakes are reduced. It stops the defects at the source, and provides immediate feedback for improvement purposes.

4.4.1.3 Plant Layout

During the lean introduction phase the change in the plant layout increases employee stress only slightly. During Lean implementation phase the change in the plant layout reduces employee stress significantly. This is indicated by a correlation of -0.14 (p=0.02). Plant layout should be redesigned to accommodate the transition to lean resulting in reduced travel time between operations, improved flow of materials and processes in the organization, reduced non-value adding activities, creating a safe accident free environment, reduced unnecessary lifting by operators, and minimized handling time. In other words, a better plant layout is a necessity for an effective lean implementation.

4.4.1.4 Cell Design

Cells are groups of activities or processes combined together to reduce non-value added cost. Stress reduction is maximized if cell design is implemented during the lean implementation phase, indicated by a significant correlation of –0.15 (p=0.01). Therefore, cells implemented during the lean introduction phase and lean refinement phase do not have as great of an impact as they may during the lean implementation phase.

4.4.1.5 Signaling System for Production

A Kanban or ConWIP card system, otherwise known as a signaling system are used to reduce the work in process and set the pace for production as per the bottleneck activity. A signaling system helps in communicating production demands at each activity. This study shows that use of a signaling system during the lean introduction phase has the maximum impact during the lean implementation phase indicated by a correlation of –0.17. A correlation of -0.09 indicates that fine-tuning of the signaling system is necessary

to reduce stress during lean refinement phase. On the whole a reliable signaling system will help in designing cells and assigning a single operator to perform multiple tasks.

Signaling systems should be developed and implemented to control production and flow of materials. An effective signaling system will help in reducing inventory, reduce wastages due to quality issues, utilize man-hours effectively, reduce lot size, and move towards one piece flow of materials enable production of multiple products during the same shift (however it is important to introduce setup time reduction and single minute exchange of dies if multiple products are to be produced during the same shift).

4.4.1.6 Visual Control for Communication

Visual controls are controls that are visually displayed in a manufacturing arena. Examples of visual communications include pictures showing how to operate a machine, lights indicating the operation condition of a machine; markers showing inventory level and reorder point in storage areas.

Visual control systems incorporated in a new plant layout may help communication between operators and superiors. An effective visual communication system will reduce confusion and reduce non-value adding time and activities while transmitting valuable information. The study indicates that an effective use of visual control systems has a great influence in reducing stress during the lean introduction phase by a correlation of –0.29 ($p=0.05$). However, it does not have great impact during lean implementation and lean refinement phases.

4.4.1.7 Product Mix

Product mixing is the ability of a facility to produce a variety of products. A correlation of –0.13 ($p=0.01$) illustrates a relationship between stress and product mixing.

This correlation indicates that with higher product mixing employee stress decreases. This is observed during the lean implementation phase. A correlation of 0.08 during the lean refinement phase indicates that with higher product mixing the stress in employees increases, however this is not a significant correlation. The possible reason for lower stress with higher product mixing is that employees have a variety of products to work and do not suffer from stress associated with repetition.

4.4.1.8 Quick Response to Production Emergency

Quick response to emergences is a very stressful activity in any phase of lean implementation. This is indicated by a correlation of 0.62 ($p<0.001$), 0.37 ($p<0.001$), and 0.38 ($p=0.0005$) in respective three phases. This implies that organizations need to have maintenance programs to reduce emergency stops in production. It is observed that emergencies are the main cause of stress in employees in the lean introduction phase.

4.4.1.9 Company Focus on Product Quality

Organizations implementing lean have to start implementing quality issues from the introduction phase; when these programs have a maximum impact on reducing stress in employees. A correlation of -0.38 ($p=0.01$) and –0.26 ($p<0.001$) illustrate this during the lean introduction and lean implementation phases respectively.

Identification of quality issues should be addressed during the introduction and implementation phases of lean. Changes to help quality are not very effective if implemented during the lean refinement phase, illustrated by a correlation of 0.03.

It is observed that many quality and customer delivery issues have common root causes. Stress in employees reduces, as employees become aware of Statistical Process Control (SPC) issues right from the inception of the lean introduction phase.

4.4.1.10 Company Focus on Customer Delivery

Breakdown and changeover (setup reduction) have an impact on machine availability. Machine availability is a fundamental resource of any lean environment and very paramount for any truly successful implementation. As inventory levels are reduced the uptime of machinery becomes even more important since there is little inventory to buffer up unplanned downtime in a lean environment. When a machine goes down the entire production line goes down affecting customer delivery. Hence a focus on customer delivery will lead to a TPM program supporting lean implementation.

Customer delivery is made possible with the help of the following tools: Total Preventative Maintenance (TPM) program, production balance, efforts to reduce setup time and others. Initial focus by companies on customer delivery issues during the lean introduction and implementation phases lowers stress levels in employees as illustrated by a correlation of –0.33 ($p=0.02$) during the lean introduction phase and –0.16 ($p= 0.007$) during the lean implementation phase.

4.4.1.11 Employee Training

It is very important to train employees in the concepts or operations that are being implemented in the different phases. It is helpful to train employees during the lean implementation phase resulting in reduced stress levels as illustrated by a correlation of 0.45 ($p<0.001$). Any sort of change can be effectively handled by training the employees to be prepared for change that may be implemented.

4.4.2 Lean Human Aspects

These include the culture of the organization and reaction of employees to change in the work environment (as shown by pillars of lean manufacturing in figure 1). This

section illustrates the key human principles or factors of lean manufacturing and the correlation it has within various phases of implementation elaborated in Table 11.

4.4.2.1 Multi-Tasking Operators

Lean hypothesizes that operators or employees should be made responsible for more than one machine, which is a key feature of cellular manufacturing. The correlation increases from 0.04 in lean introduction phase to 0.05 in lean refinement phase. This feature can be the source of stress in employees and operators, which is indicated by the correlation. However, adequate attention should be given while training employees (operators and managers). Employees should be open-minded with the concept of multiple allocations of machines to a single operator to reduce the consequence of stress.

4.4.2.2 Employees with Increased Responsibilities

Increasing employee responsibilities helps give them more autonomy as well as offering them job growth. A positive correlation of 0.40 ($p=0.007$) during the lean introduction phase indicates that increased responsibilities results in increased employee stress. However, during the later phases of lean implementation stress is reduced with these increased responsibilities. This is indicated by a correlation of –0.19 ($p=0.001$). Furthermore, a superior who facilitates, or helps rather than supervising is significantly correlated to reducing stress during the lean refinement phase illustrated by a correlation of 0.23 ($p=0.03$).Increasing responsibilities for employees encourages and offers a sense of belonging and help employees implement their ideas, detect problem areas, and implement corrective measures to reduce wastages of various resources. However prior to dissipation of responsibilities it is important to identify the responsibilities and sensitive issues to avoid conflict amongst employees.

Table 11: Human issues faced during Lean transition

Question Numbers	Lean Human Issues	Lean Introduction Phase *	Lean Implement Phase *	Lean Refinement Phase *
6	Operators are responsible for more than one machine	0.04	0.03	0.05
7	Operators have responsibilities other than operating the machine	0.40	-0.19	-0.16
10	Operators have control over the production flow	-0.34	-0.07	0.05
13	Operators make quick decisions for immediate problem solving	-0.20	-0.15	0.12
16	Operators have tension with superiors	0.08	0.49	0.24
9	Supervisor more as a facilitator rather than supervising	0.12	0.05	0.23
17	Superiors give adequate feedback on performance	-0.05	0.002	0.04
22	Support personnel are too few	0.30	0.33	0.43
23	Support personnel are incompetent	0.54	0.31	0.57
12	Compensation based on individual contribution	-0.58	0.14	0.13
8	Work groups and teams the mode of operation	0.15	-0.09	0.02

*All values indicated in the table show the correlation between that particular question and employee stress

4.4.2.3 Quick Problem Solving

A correlation of –0.15 ($p=0.01$) during the lean introduction phase indicates that employees with quick decision making responsibilities have lower stress. But prior to introducing the concept of quick decision-making, operators should be trained adequately to make quick decisions. Quick decision making techniques significantly help to reduce stress during the lean introduction phase. However, the significance reduces with further advancement into the lean execution phase.

4.4.2.4 Operator and Management Tension

Tension between management and operators can be stressful. This is clearly related to stress by a correlation of 0.08 ($p=0$), 0.49 ($p<0.001$), and 0.24 ($p=0.03$) in the respective three lean execution phases. This tension can be very critical in the lean implementation phase followed by the lean refinement phase. These two phases are very crucial because there has to be open lines of communication to implement lean successfully. Measures should be taken to dissipate tension amongst employees resulting in an appropriate environment for lean execution. The issue of operator and manager tension is very critical during lean execution because this is the foundation for a successful lean execution.

4.4.2.5 Performance Feedback

It is crucial for management to give critical feedback to employees on their performance. However, it does not have the most significant impact on the stress in employees in any of the phases. However it is an issue that managers should take into consideration for an effective work environment. Management giving adequate feedback about the performance of an employee will help the employee improve their

performance. However care should be taken to communicate in a way that will help the employee understand potential areas of improvement.

4.4.2.6 Support Personnel

Support personnel are very crucial in relieving stress in employees during lean execution. The research shows that support personnel should be available and competent enough to execute operator duties. Employees in all three different phases of lean execution agree that competent support personnel are significantly responsible for lowering stress. This is illustrated by a significant correlation of 0.54 ($p=0.0002$) during lean introduction phase, 0.31 ($p<0.001$) during lean implementation phase, and a correlation of 0.43 ($p=0.0001$) during lean refinement phase.

Chapter Five

Conclusion

This chapter summarizes the findings and contributions of this research. It also lists opportunities for future research. This research has hypothetical and organizational contributions.

5.1 Contributions of the Research

1. Past research associating employee stress to Lean:

An extensive literature search indicates that there is not enough research conducted in the area of employee stress and Lean. The search led to different research's that elaborate the advantages and disadvantages of Lean and stress, but there is no single research that emphasizes or explains the relationship of employee stress and Lean.

2. Relationship between employee stress and Lean:

This research hypothesis that "Lean implementation increases employee stress". A negative correlation is established between employee stress and Lean. The regression analysis and hypothesis test supports this negative correlation. This indicates that as Lean progresses employee stress reduces. This finding adds to the theory of Lean and provides future researchers and companies a correlation by which to compare various lean activities.

3. Level of employee stress in each phase of Lean:

This research introduces the concept of different phases of Lean which are Lean Introduction Phase, Lean Implementation Phase, and Lean Refinement Phase. Furthermore this research investigates the impact Lean has on employee stress during these various phases. A significant finding of this research is that it shows evidence that

employee stress reduces within each phase of Lean. This finding can be used by future researchers to predict employee stress based on the Lean phase. For decision-makers the study can also be used to develop a strategy in terms of various Lean tools that can help reduce employee stress and hence resistance to change.

4. Lean principles that influence employee stress in each Lean phase:

This research analyzes Lean technical issues and Lean human issues within each phase of Lean execution and understands their correlation to employee stress. Lean technical and human issues that have a significant correlation in reducing employee stress can be used to develop an implementation strategy for decision-makers. This is the most significant managerial contribution of the study towards Lean executing organizations.

5. Management guidelines for employee management through different phases of Lean:

This research gives managers a guideline for Lean execution based on the employee stress levels. Lean technical issues and Lean human issues are the two broad categories for these guidelines.

5.2 Research Conclusions

The hypothesis of these research was "Lean implementation increases employee stress". Based on this hypothesis the following conclusions are made,

1. There is a negative correlation between Lean implementation and employee stress.
2. There are three distinct phases of Lean: Lean Introduction Phase, Lean Implementation Phase, and Lean Refinement Phase.

3. Employee stress reduces from Lean Introduction Phase to Lean Refinement Phase.
4. There is a slight increase in employee stress at the start of each Lean phase.
5. Lean principles can be categorized into Lean Technical Issues and Lean Human Issues.
6. Every Lean principle has a different correlation on employee stress during various Lean phases.

5.3 Scope for Future Research

The short-term results of lean implementations (like 5S implementation) are considerably successful however the actual long-term implementations (like kanban system) have significant performance gaps with expected outcomes. A study of the causes of such a performance gap is needed. A possible future study hypothesis may be: "Long-term lean implementations are more stressful than short term lean programs"

Lean implementation programs are not successful without an effective training program for the employees. With focus on training people, organizations can concentrate on problems faced by employees during implementation and encourage systems that integrate problem solving at every level of the organization. A probable area for future study would be to study the impact of various training programs on employee responses to lean implementation. The following hypothesis is suggested for future studies: "Human aspects of Lean are more stressful than technical aspects of Lean" Future study perhaps needs to identify the effect of Lean in non-production organizations (like the service sector), as this study was exclusively designed for manufacturing sector.

Future researchers may want to take into consideration several items prior to collecting samples. These items were not considered in this research project, however, may be of interest for future researchers. This section provides a discussion of these items that may help future researchers.

- This research exclusively address employee stress caused due to work related activities. This research does not identify or measure sources of stress other than that at the workplace.
- Change in management and their policies may be a major source of employee stress. This is an area that future researchers can incorporate in their studies.
- This research was conducted in organizations without prior knowledge of the organizations Lean activities. The pilot study was conducted in the same manner hence there is no assurance that there is a statistical relationship between the pilot study and the samples.
- The intent of the pilot test was to check for statistical consistency among the responses. The consistency is achieved by collecting the samples for the pilot test from the same group of employees, which was not achieved by this research.

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Appendices

Appendix A

Explanation of Various Terms Used

1. Level of perception of Lean: It is the awareness or understanding of the Lean tools and continuous improvement techniques.
2. Phases of Lean: Lean implementation is a continuous process. But for this study it is proposed that Lean in implemented in a discreet manner. There are three distinct phases of Lean Implementation.
   a) Lean introduction phase: This is the phase when employee's perception about lean is very introductory, that is, they have brief theoretical and practical introductions to simple lean tools and techniques.
   b) Lean implementation phase: This is the phase where employees are implementing lean tools and techniques. They are required to have higher awareness about lean tool and techniques.
   c) Lean refinement phase: This is the phase where employees are at a very high awareness level about the lean tools and techniques. They have implemented the important lean tools and are working towards fine-tuning the different lean tools.
3. Data Collection: The survey instrument is given to employees who are willing to participate in the survey. The participation or outcome of the survey in no way has an impact on the performance review of the employee (this is made clear to the employees prior to distributing the survey instrument). First page of the survey instrument gives information regarding the age, sex, position held in the organization, and shift.
   a) Lean Environment Evaluation Profile (LEEP): LEEP tells us about the perception of an employee about Lean tools and its execution in the organization. A total of

fifteen questions are included in the LEEP. These questions are scored on a scale of 1 to 10. 1 being the minimum score and 10 being the maximum score, a total of 150 points can be scored on the LEEP. The higher the score on LEEP will indicate the employee's higher awareness about Lean tools and its execution in the organization. However, this profile will just give the perception of the employee and not the actual phase of Lean execution in the organization.

b) Work Stress Profile (WSP): WSP indicates the work stress in employees. This tool has been adapted from a survey questionnaire designed by Phillip L. Rice in his book "Stress and Health" edition three, 1999. There are fifty-seven questions in the questionnaire that measure stress in an employee. The questions are measured on a scale of 1 to 5 with 1 being the least score and 5 being the highest score. If the total of the score from all the questions is 141 and above the employee is considered to be stressed at their job, scores between 111 and 140 is considered to be normal stress, and scores below 111 are categorized as low stress.

4. Relationship between LEEP and WSP: The LEEP gives the perception of an employee about Lean tools and its execution in the organization. The WSP gives the stress level of the employee (who has already taken the LEEP). The combination of LEEP and WSP help identifying the relationship between employee stress and Lean.

Appendix B

Survey Instruments

Distinguishing Factors for a Lean Manufacturing Facility

- Name of the organization:

- Address:

- Number of Employees in the facility:
  Managerial/Administrative:
  Production:
  Others (Specify):

Responsibility/Position in the organization:

Age: Sex:

Shift number:

Products Manufactured:

The Lean-Environment Evaluation Profile (LEEP)

Instruction:

Circle the answer that best reflects your working conditions at your workplace of employment 1 being the minimum and 10 the maximum

1) Does the layout of the plant help in reducing travel time?
1 2 3 4 5 6 7 8 9 10

2) Is the layout in the form of distinguishable cells?
1 2 3 4 5 6 7 8 9 10

3) Do you use any sort of signaling system so as to improve production flow?
1 2 3 4 5 6 7 8 9 10

4) Are you currently producing in smaller lot size than before?
1 2 3 4 5 6 7 8 9 10

5) Is the production system set up such that it can produce variety of products?
1 2 3 4 5 6 7 8 9 10

6) Are operators responsible for more than one machine?
1 2 3 4 5 6 7 8 9 10

7) Do the operators have additional responsibilities other than operating the machine? (Like cleaning, inspection etc.)
1 2 3 4 5 6 7 8 9 10

8) Are work-groups and teams the mode of operation?
1 2 3 4 5 6 7 8 9 10

9) Is the supervisor more as a facilitator rather than supervising?
1 2 3 4 5 6 7 8 9 10

10) Do the operators have control over the production flow?
1 2 3 4 5 6 7 8 9 10

11) Is Visual control used to increase the effectiveness of communication?
1 2 3 4 5 6 7 8 9 10

12) Is compensation based on individual contribution towards the overall performance of the company?
1 2 3 4 5 6 7 8 9 10

13) Does the company culture allow the operators to make their own decisions for immediate problem solving?

1 2 3 4 5 6 7 8 9 10

14) Does the company have focus on quality?

1 2 3 4 5 6 7 8 9 10

15) Does the company have focus on customer delivery?

1 2 3 4 5 6 7 8 9 10

What do you do to contribute to the Lean Thinking in your facility?

_____

_____

_____

_____

Work Stress Profile

Circle the answer that best reflects your working conditions at your workplace of employment

1.NEVER - not at all true of your work conditions or feelings
2.RARELY - the condition or feeling exists 25% of the time
3.SOMETIMES - the condition or feeling exists 50% of the time
4.OFTEN - the condition or feeling exists 75% of the time
5.MOST TIMES - the condition or feeling is virtually always present

1. Support personnel are incompetent or inefficient
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

2. My job is not very well defined
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

3. I am not sure of what is expected from me
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

4. I am not sure of what will be expected of me in the future
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

5. I cannot seem to satisfy my superiors
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

6. I seem to be able to talk to with my superiors
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

7. My superiors strike me as incompetent, yet I have to take orders from them
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

8. My superiors seem to care about me as person
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

9. There are feelings of trust, respect and friendliness between me and my superiors
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

10. There seems to be tension between me and my superiors
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

11. I have autonomy in carrying out my job duties
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

12. I feel as though I can shape my own destiny in this job
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

13. There are too many bosses in my area
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

14. It appears that my boss has "retired on the job"
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

15. My superiors give me adequate feedback about my job performance
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

16. My abilities are not appreciated by my superiors
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

17. There is little prospect for personal or professional growth in this job
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

18. The level of participation in planning and decision making at my place of work is satisfactory
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

19. I feel I am overeducated for this job
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

20. I feel that my education background is just right for this job
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

21. I fear that I will be laid off or fired
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

22. In-service training is inadequate for my job
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

23. Most of my colleagues are unfriendly or seem uninterested in me as a person
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

24. I feel uneasy about going to work
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

25. There is no release time for personal affairs or business
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

26. There is obvious sex/race/age discrimination in this job
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

27. The physical work environment is crowded, noisy, or dirty
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

28. Physical demands of the job are unreasonable (heavy lifting, extraordinary periods of concentration required, etc)
□ NEVER □ RARERLY □ SOMETIMES □ OFTEN □ MOST TIMES

29. My work load is never ending
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

30. My pace of work is too fast
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

31. My job seems to consist of responding to emergences
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

32. There is no time for relaxation, coffee breaks, or lunch breaks on the job
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

33. Job deadlines are constant and unreasonable
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

34. Job requirements are beyond the range of my ability
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

35. At the end of the day I am physically exhausted from work
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

36. I cant even enjoy my leisure because of the toll my job takes on my energy
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

37. I have to take work home to keep up
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

38. I have responsibility for too many people
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

39. Support personnel are too few
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

40. Support personnel are incompetent or inefficient
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

41. I am sure of what is expected of me
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

42. I am not sure of what will be expected of me in the future
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

43. I leave work feeling burned out
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

44. There is little prospect for personal or professional growth in this job
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

45. In service training is inadequate for my job
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

46. There is little contact with colleagues on the job
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

47. Most of my colleagues are unfriendly or seem uninterested in me as a person
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

48. I feel uneasy about going to work
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

49. The complexity of my job is enough to keep me interested
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

50. My job is very exciting
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

51. My job is varied enough to prevent boredom
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

52. I seem to have lost interest in my work
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

53. I feel as though I can shape my own destiny in this job
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

54. I leave work feeling burned out
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

55. I would continue to work at my job even if I did not need the money
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

56. I am trapped in this job
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

57. If had it to do all over again I would still choose this job.
□ NEVER □ RARELY □ SOMETIMES □ OFTEN □ MOST TIMES

Appendix C

Responses Rejected Due to Inconsistent Answering

Table 12 below gives the details of the responses discarded due to inconsistent answering by the subject (employees)

Table 12: Responses rejected due to inconsistent answering

	Question Number											
	1	**40**		**3**	**41**		**4**	**42**		**22**	**45**		**24**	**48**
1	4	4		3	3		5	3		4	3		4	3
2	1	1		5	5		3	3		1	1		3	1
3	4	4		3	3		5	3		4	3		4	3
4	1	1		4	5		4	3		2	1		2	1
5	1	1		4	3		4	3		2	2		2	3
6	2	2		1	2		1	4		3	4		3	5
7	1	1		4	3		4	3		2	2		2	3
8	1	1		4	5		4	4		2	3		2	3
9	5	5		3	5		3	3		1	1		2	1
10	5	5		3	5		3	3		1	1		2	1
11	1	1		3	1		3	3		3	2		3	3
12	1	1		3	1		3	3		3	2		3	3
13	1	1		3	1		3	3		3	2		3	3
14	1	1		3	1		3	3		3	2		3	3
15	1	1		3	1		3	3		3	2		3	3
16	1	1		3	1		3	3		3	2		3	3
17	1	1		3	1		3	3		3	2		3	3
18	1	1		3	1		3	3		3	2		3	3
19	1	1		3	1		3	3		3	2		3	3
20	1	1		3	1		3	3		3	2		3	3
21	5	5		3	1		3	3		1	2		2	3

Appendix D

Management Guidelines for Lean Execution

Summing up below is the road map for Lean execution. This road map identifies the various key tools that have to be administered in each phase for a smooth change during transition with minimal stress on employees. On the whole, it is observed that some of the tools need to be implemented in more than one phase due to the nature of the technique that has a wide impact throughput the lean execution and is very pivotal for success.

1. Management guidelines for Lean Introduction Phase

   - Management should take steps to employ teams and groups as mode of operation. This will increase employee participation. The foremost activity of a team or group is to implement 5S activities and make it a culture of the organization helping reduce clumsy and noisy work areas.
   - Management should make arrangements to redesign the layout of the plant this will improve production flow in the organization. The layout should incorporate the use of cells for effective flow of production and reduction in wastes due unnecessary travel time.
   - Decision-makers must give employees more autonomy and encourage detecting problem areas and suggesting solutions enhancing participation. This brings about a sense of belongings. Supervisors should assume the role of facilitators rather than supervisors. Higher responsibilities will improve with higher prospect for growth and increased autonomy. Management should clearly identify work responsibilities so as to reduce confusion and ambiguity. Lower ambiguity will enhance competency and efficiency of employees.

- Managers should devise visual control systems and implement them to increase efficiency of communication. Effective and efficient communication systems will reduce wastage caused by it.
- Managers should tell employees of what is expected of them in the future so as to reduce speculation and uncertainty. The future should be made as certain as possible so as to reduce unnecessary job stress.

2. Management guidelines for Lean Implementation Phase
   - Management must encourage formation of team and groups as a mode of operation in the organization for effective implementation.
   - Managers should design and implement visual control systems for effective communication among employees and operations.
   - Managers should design effective signaling system (Kan-ban System) so as to enhance the flow of production and reduce wastages due to inventory and quality issues. An effective signaling system will enhance customer delivery system and improve the quality of the operations.
   - Managers should assume the role of facilitators rather than supervisors giving operators autonomy to control the production in case of emergencies like break down; however operators should be trained to make quick decisions for problem solving.
   - Managers should enhance employee's job by reducing confusion and role ambiguity. This will help employee's plan out the prospect of growth in the work

place. Encouraging for a friendlier work place. Greater role ambiguity leads to employees increased fear of getting fired leading to higher stress.

3. Management guidelines for Lean Refinement Phase

- Managers should devise visual control systems and effectively implement them so as to communicate effectively between operations and employees.
- Design effective signaling system (Kan-ban system) to improve production flow. Use of cell design to improve workflow and effective use of man-hours. Adjust and reduce the lot size so as to improve the production flow.
- Managers should assume the role of facilitating the employees rather than supervising. Superiors should be encouraged to give feedback on the performance of their subordinates encouraging the performance of their employees.
- Managers should empower operators to make quick decisions for problem solving. This will help in maintaining the employee interest level, reduce boredom, give employees a sense of achievement, and reduce the production downtime. Employee participation in decision-making should be increased.

4. Management guidelines to becoming a 'pioneer' Lean organization

A 'pioneer' organization is one that is advanced in all the four pillars of Lean manufacturing. A pioneer Lean organization has implemented almost all of the Lean techniques however, these implementations need to be fine-tuned and adjusted so as to satisfy different work scenarios. However following are the areas that need the most attention and changes.

Plant layout needs to be modified so as to reduce travel time and bring further flow to the production. This will also help in further reducing the non-value added time due to traveling.

Lot size has to be made smaller or adjusted to one-piece flow. Signaling system has to be improvised upon so that it does not hinder the production flow and reduce wastes due to inventory.

Operators need to be empowered to make quick decisions for problem solving. A higher degree of participation in decision-making will induce a feeling of growth on the job.

For empowering operators they need to be trained for quick decision-making and cross-trained for any emergencies. This will improve job interest and give a chance for personal growth on the job.

Vita

Naim Nezhad was born in Kolhapur, India on August 1, 1976. He completed all his schooling in India at St Xavier High School. He graduated form Shivaji University in India with Bachelors of Engineering in Production Engineering in August 1998. As an undergraduate his specialization was flexible manufacturing systems.

In Fall 2000 Naim Nezhad joined the Masters of Science program in Industrial Engineering at The University of Tennessee Knoxville. His area of specialization was in Lean Manufacturing Systems. During his graduate studies he served as a graduate research assistant for Dr. Rupy Sawhney. As a graduate research assistant he has had the opportunity to work on different projects in Lean.

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