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REGRESSION ANALYSIS OF FACTORS IMPACTING PROBLEM SOLVING ENGAGEMENT WITHIN LEAN SYSTEMS IMPLEMENTATION

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REGRESSION ANALYSIS OF FACTORS IMPACTING PROBLEM SOLVING ENGAGEMENT WITHIN LEAN SYSTEMS IMPLEMENTATION

DISSERTATION

A dissertation submitted in Partial Fulfillment of the
Requirements for the degree of Doctor of Philosophy in the
College of Engineering
at the University of Kentucky

By
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Lexington, Kentucky

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Lexington, Kentucky

2018

ABSTRACT OF DISSERTATION

REGRESSION ANALYSIS OF FACTORS IMPACTING PROBLEM SOLVING ENGAGEMENT WITHIN LEAN SYSTEMS IMPLEMENTATION

Organizations around the world have attempted to implement the concepts of the Toyota Production System (TPS), commonly referred to as Lean, with limited sustainable success. The central principles of TPS, continuous improvement and respect for people, are grounded in the Japanese values of Monozukuri and Hitozukuri. Monozukuri deals with creating or making a product, while Hitozukuri conveys the idea of developing people through learning. In order for organizations to adopt these values they must have a system that engages employees at all levels in applying problem solving to improve their work. This research uses organizational assessments obtained from a variety of organizations implementing the lean approach using the Monozukuri and Hitozukuri values, referred to as the True Lean System (TLS).

This research uses an inductive research approach to identify and analyze factors that impact the use of problem solving within organizations implementing a TLS. First, the qualitative assessment data is studied using textual analysis to identify themes impacting TLS. This analysis identified three topics as the highest weighted themes: number of problem solving methods, standardization, and employee roles. This qualitative data is then transformed using an integrated design model to systematically code the information into quantitative numerical data. Finally, this data was analyzed statistically by logistic regression to identify the factors impacting the use of problem solving within these organizations.

The results from the logistic regression suggest that the most successful problem solving organizations have established standards for work and training employees; as well as, a single problem solving method that all employees use when identifying and implementing continuous improvement ideas. Which leads to the conclusion, in order for an organization to sustain the concepts of TPS, there must be a focus on defining clear standardized work, training, and the implementation of a single problem solving method.

KEYWORDS: Lean systems, Problem Solving, Toyota Production System, Continuous Improvement, Logistic Regression

David M. Parsley, II

April 12, 2018

Date

REGRESSION ANALYSIS OF FACTORS IMPACTING PROBLEM SOLVING ENGAGEMENT WITHIN LEAN SYSTEMS IMPLEMENTATION

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This dissertation is dedicated to my very patient family: Gina, Gabriella, David & Gretchen.

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I would like to thank everyone who supported me during the development of this research project.

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CHAPTER 1: INTRODUCTION

The term "lean" was first coined by Womack and Jones in 1990 when conducting a five year worldwide benchmarking study of the automotive industry (Womack, Jones, & Roos, 1990). In this study Womack and Jones were able to document a trend at Toyota plants that reduced cost while increasing quality and efficiency that was not duplicated by other automakers. This led to a movement of organizations around the world attempting to copy the elements of the Toyota Production System (TPS) in order to replicate the same results.

The foundational core principles for TPS were documented by then President of Toyota Motor Corporation, Fuijo Cho, in a document called The Toyota Way 2001 (Toyota Institute, 2001). Figure 1.1 shows the principles documented in the Toyota Way 2001.

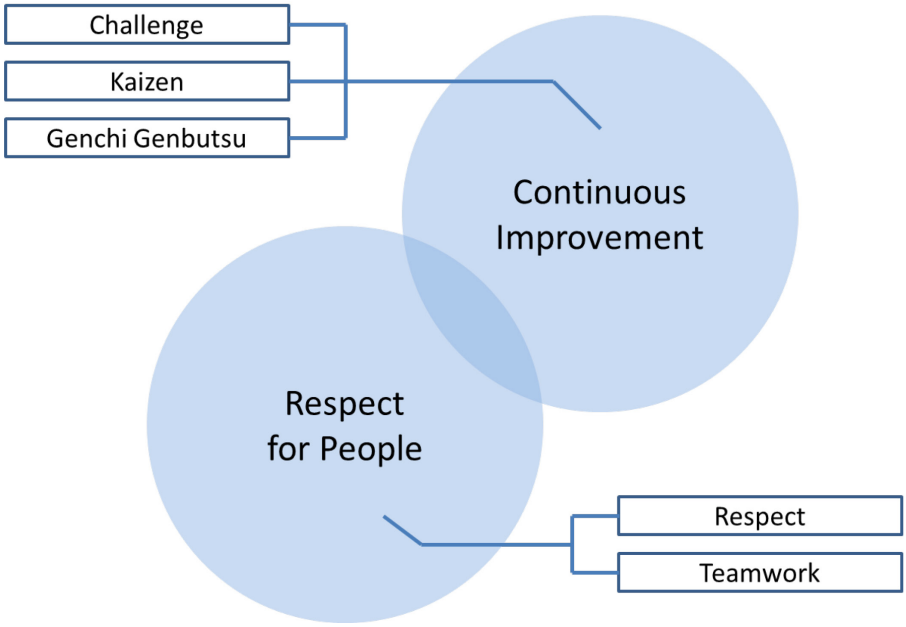

Figure 1.1: Toyota Way Principles (Toyota Institute; 2001)

These principles of continuous improvement and respect for people, and can be traced back to the Japanese values of Monozukuri and Hitozukuri (Saito, Salazar, Kreafle, & Grulke, 2011). In Japanese, Monozukuri can be translated as the process of making or creating, but as Saito points out in his article, the word has "overtones of excellence" and carried out with "creative thinking" by the people doing the work (Saito, Salazar, Kreafle, & Grulke, 2011). As for the second value, Hitozukuri, it can be translated as education, and can be thought as a life-long passion for learning and development (Saito K. , Kufu: Foundations of Employee Empowerment and Kaizen, 1995). So, for TPS to work properly the organization must have a lean system in place that supports both the Monozukuri and Hitozukuri values (Cho, Hitozukuri and Monozukuri, 2005). Figure 1.2 is an image by Saito to show how these two values work together within a system (Saito, Fuijo Cho Legacy Lecture: Hitozukuri and Monozukuri, 2010).

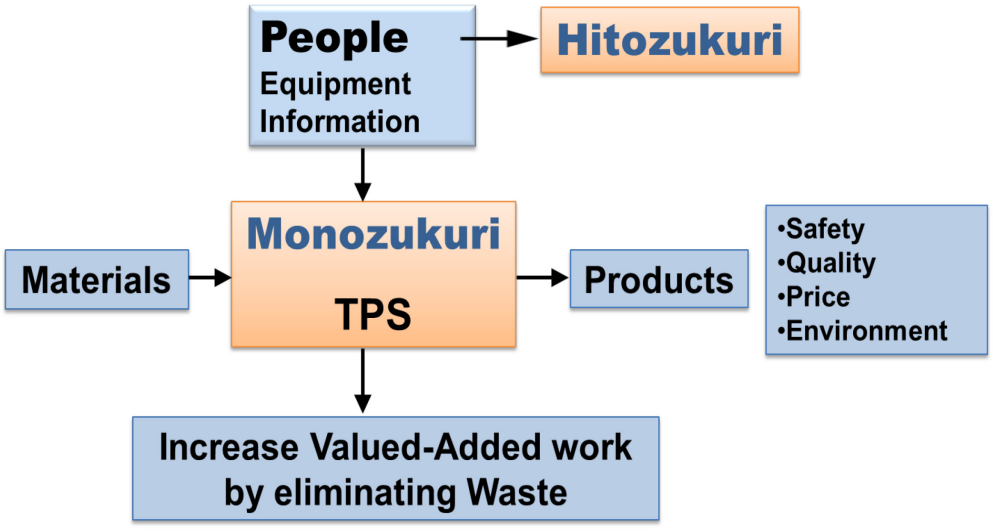

Figure 1.2: Hitozukuri and Monozukuri (Saito; 2010)

1.1 Motivation for Lean Research

The goal of TPS is simple, to provide customers a high quality product, at lowest cost, in a timely manner (Ohno, Toyota Production System: Beyond Large-Scale Production, 1988). However, for organizations outside of Toyota, it has been hard to adopt and sustain. An Industry Week study conducted in 2007 found that 74% of companies that were attempting to apply TPS within their organizations were making little to no progress (Pay, 2008). There is plenty of research one can find studying the impact that lean has on production systems results, but these studies are typically related to improving processes by applying lean "tools". Typically organizations focusing on adapting lean concepts will attempt to apply tools related to standardization (i.e. 5S, visual control, standard work) (Filip & Marascu-Klein, 2015), (Lu & Yang, 2015) , continuous flow (Rahani, 2012), and pull production (Sugimori, Kusunoki, Cho, & Uchikawa, 2007). These elements are what we will refer to as the Monozukuri application of TPS.

Some of these lean concepts have different meanings within organizations; however, in this study the terms will be defined from the Toyota framework since it is a study on companies adopting TPS ideas. 5S, commonly referred to as 4S within Toyota, are a set of activities that are performed to clean and organize a work environment to a standard condition. This is considered by many organizations as the starting point for the implementation of TPS practices. However, many organizations that start with the adoption of 5S are unable to engage employees to maintain the standards established through the 5S activities. In terms of visual control, common lean practices that have been adopted from Toyota are the ideas of andon, which means "lantern" and highlights with an employee encounters a problem, and the idea of kanban which is an information card that

informs employees when to produce parts needed for a customer. Standard work is centered on people's motion to create an efficient work sequence that minimizes unnecessary actions. The idea of continuous flow means that as material moves through the production system it does not stop and wait in a storage location like a warehouse, but it flows quickly to the next process. Finally, pull production within TPS means that nothing is produced by the production system processes until it is needed by the customer. The order from the customer informs the processes when to produce, what product to make, and the quantity needed by the customer. The Pull System flow is managed through the use of the kanban cards. (University of Kentucky, 2008) Appendix A contains a longer list of terms and definitions for common lean concepts.

While the application of these tools can provide operational benefits, many times the gains aren't sustained and the organization falls back into old behaviors (Glover, Farris, & Van Aken, 2015). In order to keep this relapse from happening, leadership within the organization will typically hire consultants or designate lean champions who are responsible to keep the lean tools operating with the shop floor (Sundar & Balaji, 2014). This is done by having the lean experts carry out Kaizen Events in the areas of the organization where adoption of TPS tools has slowed or begun returning to old habits (Glover, Liu, Farris, & Van Aken, 2013). Kaizen Events are defined as "a focused and structured improvement project, using a dedicated cross-functional team to improve a targeted work area, with specific goals, in an accelerated timeframe" (Farris, Van Aken, Doolen, & Worley, 2009). The same authors also identify that typically Kaizen Events are championed or sponsored by engineering managers within the organization (Farris, Van Aken, Doolen, & Worley, 2009). However, this implies that only certain individuals within

the organization are responsible to study the system and make improvements. This leaves a vast majority of untapped human potential across the organization that is able to highlight where there is waste within the system and determine how it can be removed. For this study we define "waste" as any factor which does not contribute to adding value to the product (University of Kentucky Lean Systems Program, 2010). In Ohno's book on TPS he determines that there are seven wastes that can be observed and removed from any production system (Ohno, 1988). Table 1.1 provides a description of the seven wastes identified by Ohno.

Table 1.1: Descriptions of the Seven Wastes

Waste	Description
Overproduction	Creating more than the customer needs
Inventory	Holding excess materials in anticipation of customer demand
Transportation	Movement of materials between processes
Over Processing	Doing work beyond customers' requirements
Waiting	Manpower unable to produce
Defects	Products that do not meet customer quality specifications
Motion	Manpower movement

This is where the second principle of the Toyota Way can be applied, respect for people—the value of Hitozukuri. By applying the idea of Hitozukuri the organization is focused not only on the results of the production system, but on the people within the system and how they can make improvements. Figure 1.3 shows how elements of Monozukuri and Hitozukuri combine to form what we define as a True Lean System (TLS).

The TLS is defined as all groups within the organization having the ability to improve their own work, using a systematic problem solving method, toward the achievement of the organization's targets/goals; and, this improvement only occurs because it is part of the company culture (University of Kentucky Lean Systems Program, 2010).

The Figure 1.3 shows that in order for the elements of Monozukuri within a TLS to become sustainable, then it must be supported by a solid foundation of Hitozukuri focused people who are capable of seeing waste, have a process to eliminate it (i.e. Problem Solving), and are supported by management to allow people to make those improvements. This is where the elements of Monozukuri and Hitozukuri begin to overlap to create a system. Since the most common lean tools, as described previously, are simply countermeasures, Monozukuri aspects, to overcome wastes within processes, then the organization must first provide people outlets to develop those countermeasures in practice. This means that organizations must provide people outlets to engage in making improvements to their work which is the purpose of Hitozukuri. So within the TLS the ideas of Monozukuri and Hitozukuri converge at the point where everyone within the organization is performing problem solving for their defined work responsibilities.

Hitozukuri is the foundation for Monozukuri (Cho, Hitozukuri and Monozukuri, 2005), (Saito A. a., 2012), however, it is not easy to teach and success for it is not always easy to measure. On the other hand, Monozukuri can offer specific tools which can produce outcomes and results to be measured in terms of metrics for safety, quality, price, delivery, etc. So companies and organizations focus only on Monozukuri and often neglect the hidden but very important aspects of Hitozukuri. Hitozukuri is the process, while Monozukuri is the result. This process-result relationship is similar to the TPS kaizen

principle which focuses on process improvement and treat the results as a by-product of the process.

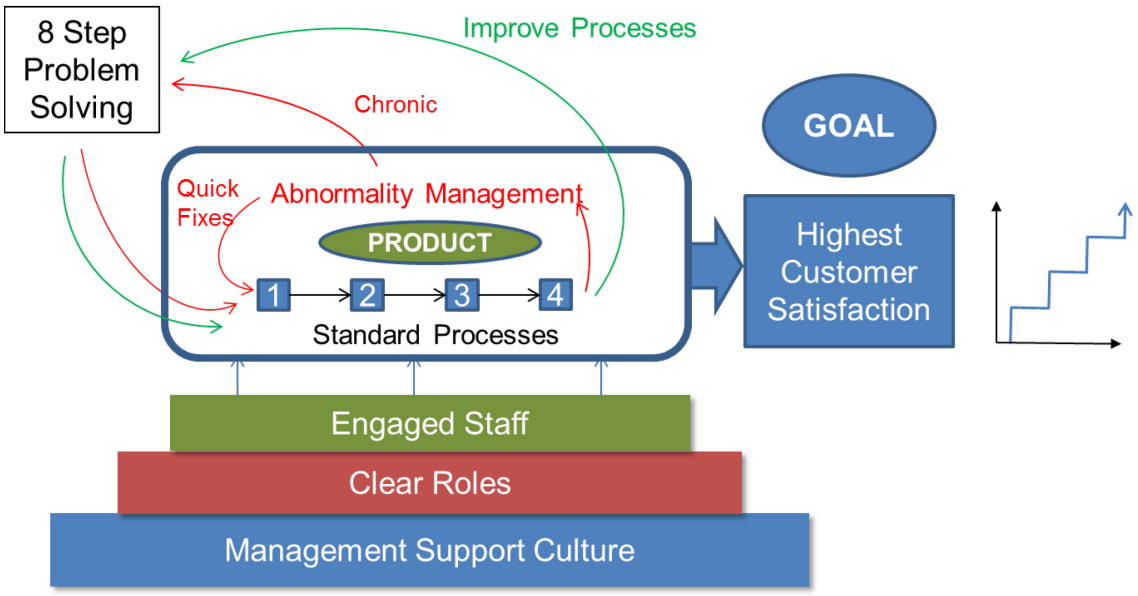

Figure 1.3: Elements of a True Lean System (University of Kentucky; 2010)

1.2 Objective of Research

The main objective of this research is to develop a model to investigate the impact that elements of Hitozukuri have on the application of Monozukuri within organizations attempting to apply concepts of TPS. Specifically, the study was focused on understanding if the following hypotheses hold true:

H_1: The use of standard job training methods for job tasks within an organization will have no impact on the engagement of people participating in problem solving activities.

H_2: The number of standard problem solving methods used within an organization will have no impact on the engagement of people participating in problem solving activities.

This research will draw on developing parameters derived from data mining of documents from multiple organizations attempting to apply TPS and create a TLS. These parameters will be validated by observations from experienced instructors conducting assessments within a sample of the same organizations. These parameters have the potential to help a multitude of organizations understand where to focus in order to apply and sustain TPS concepts based on their current conditions.

1.3 Outline of Dissertation

Chapter 1 introduces lean production systems, provides the motivation for this research, and objectives for this study.

Chapter 2 serves as the literature review for current research on lean systems and data mining. The use of data mining in production systems research is discussed

Chapter 3 introduces the mixed model approach used to create the data mining model. It describes how the data mining process was used to discover the major factors within the model.

Chapter 4 details the results of the binary logistic regression analysis of the data mining model created in Chapter 3.

Chapter 5 presents the conclusions based on the results of the models from Chapter 4, and explains limitations, and future work for the study of lean production systems.

CHAPTER 2: LITERATURE REVIEW

2.1 Background of Lean Research

The earliest research publication on lean production first appeared in 1988 in the article, "Triumph of the Lean Production System", by John F. Krafcik (Krafcik, 1988) and popularized through the book, "The Machine that Changed the World" (Womack, Jones, & Roos, 1990). Both of these early publications on lean production were the result of a five year study on the worldwide automotive production industry led by the MIT International Motor Vehicle Program. Through these early studies the benefits of the Toyota Production System (TPS) were first identified and accepted globally as the best manufacturing philosophy to remain competitive in an ever-changing marketplace where customers demand new products in shorter time to market and at lower costs (Tersine & Wacker, 2000), (Lau, Jiang, Chan, & Ip, 2002), (Ho, Lau, Lee, & Ip, 2005).

The concept of TPS was developed and implemented within Toyota between 1948 and 1975 led by Taiichi Ohno (Ohno, 1988). The official definition from Toyota for TPS says that, "TPS is a framework for conserving resources by eliminating waste. People who participate in the system learn to identify expenditures of material, effort and time that do not generate value for customers." (Toyota Motor Corporation, 1998). The most notable elements of TPS are the concepts of Just-in-Time (JIT) and Jidoka. JIT is defined as making only what is needed, only when it is needed, and only in the amount that is needed (Toyota Motor Corporation, 1998). The benefits of JIT on reducing inventory costs have been studied extensively by researchers across a variety of industries (Tiwari, Dubey, & Tripathi, 2011). Jidoka is defined as "automation with a human touch" (Ohno, 1988) where the focus is to build in quality at the source. This means that processes are setup to identify

an abnormal situation immediately, stop the process, and fix the problem. The idea of Jidoka helps to detect problems at the source and identify solutions to prevent defect recurrence. Figure 2.1 shows the Toyota Production System (TPS) House which Ohno created to explain how the main elements of TPS fit together.

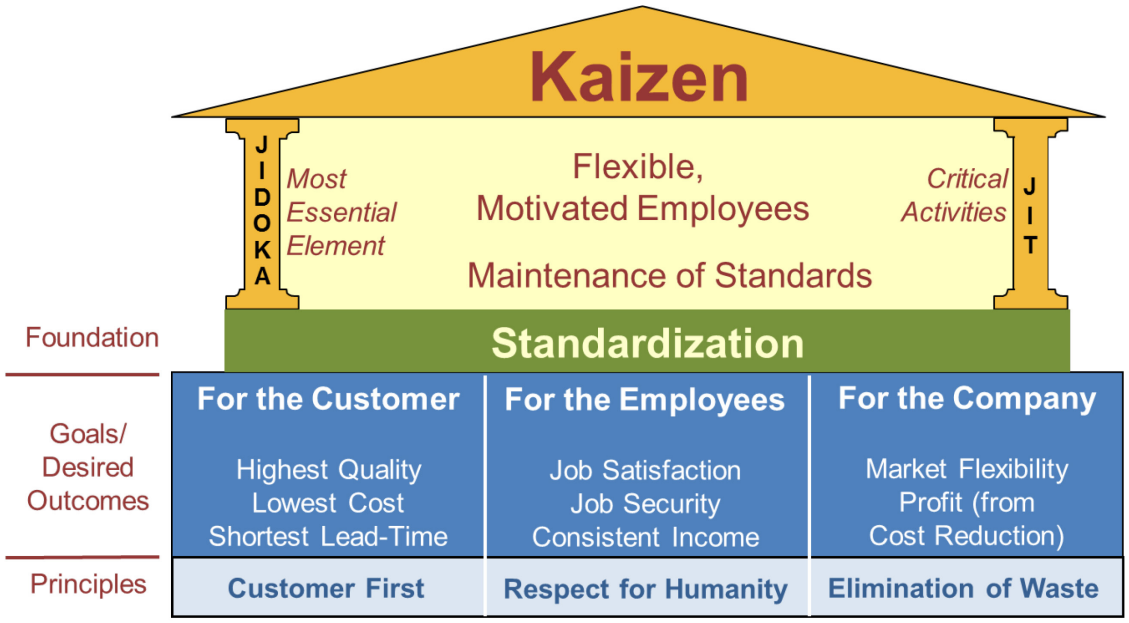

Figure 2. 1: Schematic of the TPS House (University of Kentucky; 1994.)

Jasti and Kodali provided in a recent review of research trends on lean systems a total of 546 peer-reviewed publications on lean topics from 1988 to 2011 (Jasti & Kodali, 2015). Their study on lean systems research trends identified the top 25 elements of lean being applied across a variety of organizations and countries. The breakdown of these 25 elements, shown below in Table 2.1, identifies that the most commonly researched topics of lean systems focuses on the application of lean tools to aid in the implementation of the

TPS pillars of JIT and Jidoka. Jasti and Kodali's research also shows high interest in the lean principle of Kaizen, known as continuous improvement in the West, which was however identified by Ohno as the last piece of the TPS house to implement. Ohno noted when he was developing TPS that the organization could not focus on implementing the ideas of Jidoka, JIT, and Kaizen without first having a strong foundation of Standardization. Ohno states that, "High production efficiency has been maintained by preventing the recurrence of defective products, operational mistakes, and accidents, and by incorporating workers' ideas. All of this is possible because of the inconspicuous standard work sheet." (Ohno, 1988). Lean researchers have noted that many of the organizations studied fail to sustain the initial gains from lean implementation over time (Mohanty, Yadav, & Jain, 2007). This inability to sustain the gains from lean falls back on how it has been implemented; where organizations choose to implement certain tools of the lean instead of implementing the complete lean system without a clear direction on how to start (Hines, Holweg, & Rich, 2004), (Holweg, 2007), (Pettersen, 2009).

Table 2.1: Breakout of Research on Lean System Elements (Ref: Jasti and Kodali, 2015)

Lean System Elements	Total Articles Mentioned	Percentage of Total Articles
Value Stream Mapping	179	32.78%
Set-up Time Reduction	171	31.32%
Kaizen	164	30.04%
Kanban	164	30.04%
Pull Production	137	25.09%
Small Lot Size	134	24.54%
JIT Purchasing	128	23.44%
Elimination of Waste	126	23.08%
Supplier Involvement	123	22.53%
Total Quality Management	119	21.79%
5S	115	21.06%
Standardization of Work	112	20.51%
Flexible Information System	108	19.78%
JIT Production	99	18.13%
Takt Time	90	16.48%
Continuous Flow	89	16.30%
Employee Commitment	86	15.75%
Multifunctional Employees	85	15.57%
Long-term Supplier & Customer Relationship	85	15.57%
Top Management Commitment	80	14.65%
Total Productive Maintenance	79	14.47%
Customer Involvement	75	13.74%
Uniform Work Load	71	13.00%
Visual Factory	62	11.36%
Cellular Layout	62	11.36%

Why is it so difficult to sustain the initial success of lean implementation to a long term continuous practice? Fujio Cho emphasized the importance of Hitozukuri in his lecture at the University of Kentucky (Cho, 1988) and Toyota Motor Vietnam's 10th anniversary lecture (Cho, Hitozukuri and Monozukuri, 2005). Saito (Saito, Fuijo Cho Legacy Lecture: Hitozukuri and Monozukuri, 2010) further elaborated on his lecture by bringing cultural aspects of lean, Hitozukuri and Monozukuri, to explain this difficulty. Hitozukuri and Monozukuri (both are Japanese words) which may require some explanation for non-Japanese audiences. Monozukuri consists of "mono" which means "products," and "zukuri" which means "process of making or creation". But the word means more than simply making something; it has overtones of excellence, skill, spirit,

zest, and pride in the ability to make things, good things, very well. Monozukuri is not mindless repetition; it requires creative minds and is often related to craftsmanship which can be learned through lengthy apprenticeship practice rather than the structured curricula taught at traditional schools. Monozukuri represents the maker's philosophy of how to make things – a philosophy deeply rooted to Japanese tradition in Zen and Confucius's teaching (Suzuki, 1973), (Saito, Fuijo Cho Legacy Lecture: Hitozukuri and Monozukuri, 2010); two important pillars that supports the century old Japanese culture. Monozukuri is therefore a philosophy rather than a technique or method.

If "mono" is replaced with "hito" which means human, Monozukuri becomes Hitozukuri. Education is the closest English word. However, Hitozukuri contains a much broader meaning and stresses a life-long process of learning. Hitozukuri emphasizes several different steps of human development, whose original form was emphasized by Confucius in his famous six different human development stages. It goes: "when I (Confucius) was fifteen year's old, I decided to study; at thirty I became independent; at forty I focused; at fifty I realized my mission in my life; at sixty I became able to listen to people without bias and prejudice; finally at seventy I attained the stage that my thinking and action are harmonized with nature" (Eno, 2015). Hitozukuri is a continuous life-long process of human development, which provides endless Kaizen opportunities within lean systems.

What is important in the above discussions is Hitozukuri comes first then Monozukuri follows. This order is crucial when a successful lean implementation is sought. It is through the Hitozukuri aspect of the lean system that the organization is able to teach everyone within the organization how to apply the Monozukuri elements within

their respective roles. One critical area for lean system implementation where the interaction of Monozukuri and Hitozukuri can be seen is in process standardization. The goal of process standardization is to maintain consistency in terms of repeatability and stability of output in terms of safety, quality, productivity and cost. Maginnis was able to show that by focusing on standardization before attempting to implement continuous improvement through problem solving provided the biggest impact on operational performance and team member (process operators) learning (Maginnis, 2012). To achieve consistency, each process must have clearly documented standardized work, a method to identify wastes, and a trained workforce that is capable of following the standardized work. Once a process has achieved this level of standardization then continuous improvement can occur through problem solving to further improve a higher level of consistency. Figure 2.2 shows how process standardization and continuous improvement link together.

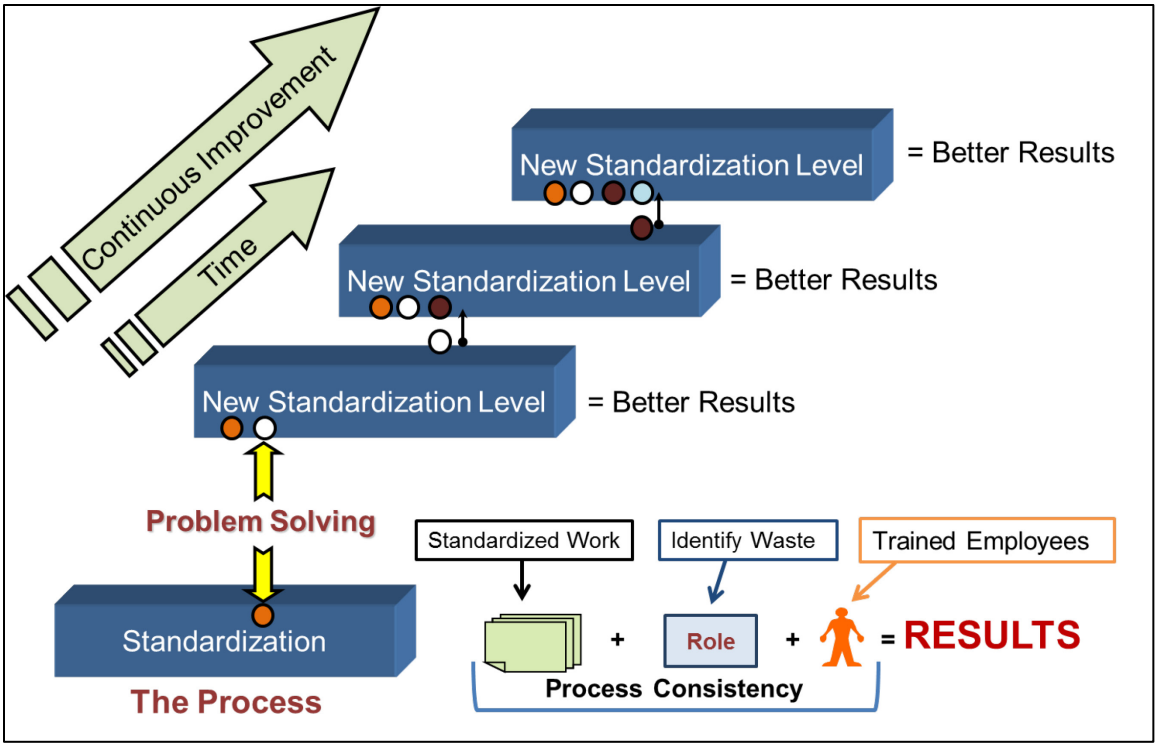

Figure 2.2: Standardization and Continuous Improvement (University of Kentucky; 2010)

The significance of education and training has been highlighted as an important success factor when implementing any changes to a production system (Zhu & Meredith, 1995), (Hameed & Waheed, 2011). Noe defines training as "an organization's planned effort to facilitate employees' learning of job related competencies" (Noe, 2008). It is necessary to develop a proper and standardized training process which can protect workers when they are completing the standardized work safely and conducting quality specifications in a timely manner. Dessler identifies ten different training methods used in a variety of organizations and work settings which are commonly used to provide employees the basic skills need to perform job duties (Dessler, 2003). These training methods are shown in Table 2.2.

Table 2.2: Types of Training Methods (Dessler; 2003)

Training Method	Key Points
On-the-job Training (OJT)	The trainee learns by doing the job
Apprenticeship Training	Trainee becomes skilled through a combination of classroom instruction and OJT
Informal Learning	The trainee learns through informal means of performing the job daily
Job Instruction Training (JIT)	Providing the trainee step-by-step training of job tasks, key points, and reasons
Programmed Learning	Present facts, allow the trainee to respond, and provide immediate feedback
Literacy Training	Testing trainees' current skills and setup programs around desired skills
Audiovisual-based Training	Training using audio/video tapes to expose trainees to situations not easily demonstrated in lecture
Simulated Training	Training use off-the-job equipment, computer based training, electronic performance support systems or learning portals

2.2 Background of Data Mining

Data Mining can be defined as "the process of discovering useful patterns and trends in large data sets" (Larose & Larose, 2014). The term data mining first appeared in a research publication by Lovell in 1983 (Lovell, 1983). The concept of data mining is grounded in the areas of statistics, machine learning, knowledge discovery, database research, and artificial intelligence (Fayyad, Piatetsky-Shapiro, & Smyth, 1996), (Smyth, 2000). There are two main types of data mining models (Kantardzic, 2003):

1. Predictive: Using variables or fields of the data set to predict future values of other variables of interest

2. Descriptive: Using the available data set to produce new, nontrivial information; uncovering patterns and relationships in the data set.

Both predictive and descriptive data mining models are developed to perform one of the following tasks:

1. Classification: *Predictive learning that classifies data into one of several predefined classes.*
2. Regression: *Predictive learning to map data to a real-value prediction variable.*
3. Clustering: *Descriptive method to identify a finite set of categories or clusters that describe the data.*
4. Summarization: *Descriptive method to find a compact description for a set of data.*
5. Dependency Modeling: *Finding a local model to describe significant dependencies between variables in a data set or part of a data set.*
6. Change and Deviation Detection: *Uncovering the significant changes in the data set.*

Source: Kantardzic, 2003

These data mining techniques require the use of structured data sets. Structured data sets are typically stored in databases and have a highly organized format so that the information can be indexed and searchable. This organization also makes it easy to apply mathematical models to uncover relationships and patterns across variables within the data set. However, the majority of data sets that are used in making decisions, particularly within business, are characterized as unstructured data; typically held in the form of word text documents. Since this information is not structured and organized, it can't be processed using

traditional data mining techniques. This is where the field of text mining was developed to help transform this unstructured textual information into structured data sets that can then be analyzed to uncover patterns and relationships like traditional data mining. Text mining is a combination of information retrieval, natural language processing, statistics, machine learning and exploratory factor analysis techniques which make it useful in a variety of research fields and industries. Figure 2.3 shows how text mining interacts with six different fields of study. Miner, et al categorizes text mining in seven areas of practice (Miner, Delen, Elder, Fast, Hill, & Nisbet, 2012):

1. **Search and information retrieval (IR):** Storage and retrieval of text documents, including search engines and keyword search.
2. **Document clustering:** Grouping and categorizing terms, snippets, paragraphs, or documents, using data mining clustering methods.
3. **Document classification:** Grouping and categorizing snippets, paragraphs, or documents, using data mining classification methods, based on models trained on labeled examples.
4. **Web mining:** Data and text mining on the Internet, with a specific focus on the scale and interconnectedness of the web.
5. **Information extraction (IE):** Identification and extraction of relevant facts and relationships from unstructured text; the process of making structured data from unstructured and semi structured text.
6. **Natural language processing (NLP):** Low-level language processing and understanding tasks (e.g., tagging part of speech); often used synonymously with computational linguistics.

7. **Concept extraction:** Grouping of words and phrases into semantically similar groups.

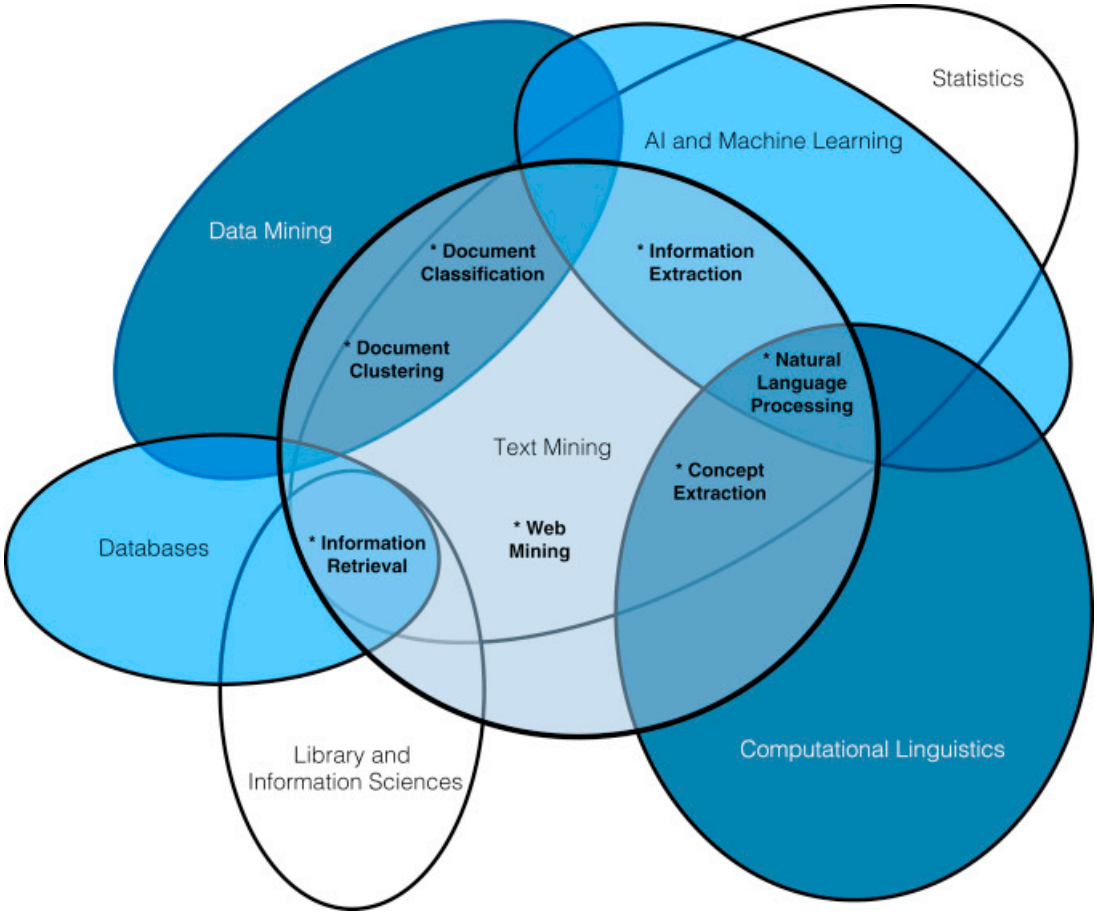

Figure 2.3: Interaction of Text Mining and Related Fields (Source: Miner, et al; 2012)

CHAPTER 3: METHODS & RESEARCH DESIGN

3.1 Introduction

This study is focused on understanding the interaction between the Hitozukuri and Monozukuri elements on companies attempting to implement the TLS. The data for this study was obtained by surveying 213 participants from a variety of organizations engaged in the True Lean Systems Certification Course. By focusing the study on this set of participants, it ensured that each respondent had a consistent understanding of each topic on the questionnaire. Since many of the lean topics have varying definitions based on interpretation of the concept attempting to send this survey to a wider population would have added considerable variation to the data, therefore, it was necessary to use the focused participant group.

The results of this study may help to understand what organizations can focus on to set up and maintain the TLS. The TLS is modeled after Toyota where everyone within the organization is able to engage in continuous improvement of their work through the use of a structured problem solving methodology. To create this organizational environment that is open to continuous improvement is founded on the establishment of clear roles, standard work, clear training, and a consistent problem solving methodology.

The remainder of this chapter will cover the inductive research approach applied to this study and discuss why the inductive approach was chosen. The mixed model research method carried out during this study will be explained. Finally, the data collection method and tools will be described to show what data was collected and how it was analyzed.

3.2 Research Approach

For this research study, an inductive research approach will be applied. In inductive reasoning, the researcher begins with specific observations, and data sets then search for patterns based on this data in order to build a theory (Goddard & Melville, 2004), (Bernard, 2011). Some researchers refer to inductive research as the "bottom up" approach since it starts with data collection through observation to arrive at conclusions or theories (Trochim, 2001).

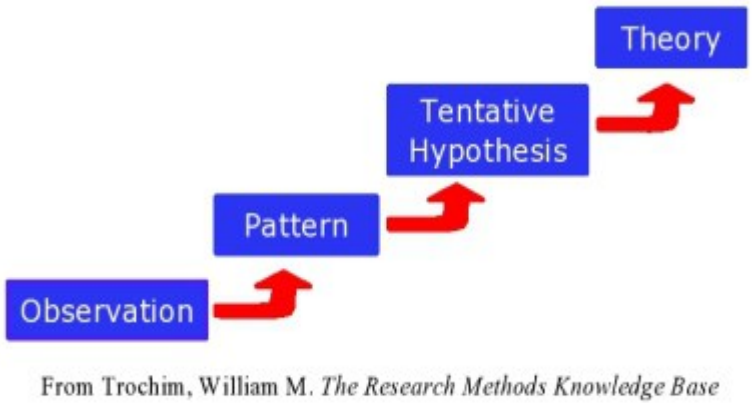

Figure 3.1: Inductive Reasoning (source: Trochim, 2001)

Thomas (Thomas, 2006) states that:

> "The primary purpose of the inductive approach is to allow research findings to emerge from the frequent, dominant or significant themes inherent in raw data, without the restraints imposed by structured methodologies. Key themes are often obscured, reframed or left invisible because of the preconceptions in the data collection and data analysis procedures imposed by deductive data analysis such as those used in experimental and hypothesis testing research."

Since there are not well established and testable theories for the implementation of lean production systems a more open-ended and exploratory approach must be taken; therefore an inductive research approach was selected.

3.3 Research Method

For this study a mixed model research method will be applied. Creswell (2003) defines a mixed model method as:

> A mixed methods study involves the collection or analysis of both quantitative and/or qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and involve the integration of the data at one or more stages in the process of research.

The mixed model method is beneficial because it will take advantage of qualitative data that contributes to theory building (Laurent, 2000), (Tomczak, 1992) and provides a better understanding of complex organizational systems (Healy & Perry, 2000), (Deshpande, 1983), but will maintain the rigor required in research by transforming the data into quantitative results which can be tested using traditional statistical methods (Srnka & Koeszegi, 2007). There are a variety of mixed models for using this blended qualitative-quantitative approach in a variety of research fields. The most common of the mixed model methods can be categorized as either a two-study design or integrated design (Mayring, 2001). Table 3.1 from Srnka and Koeszegi (2007) summarizes these common mixed model research designs.

Table 3.1: Qualitative-Quantitative Research Designs (Source: Srnka & Koeszegi, 2007)

Qualitative-Quantitative Research Designs			Mayring (2001)	Davies (2003)	Creswell (2003)	Creswell (1994)
Description Qualitative data and quantitative data are collected and analyzed in sequential order. *Aim* Investigate under-researched field, to develop hypotheses or create instruments for subsequent quantitative measurement, or provide explanations.	Two-studies designs	Sequential two-studies design	Prelimi-nary study model	Sequential design	Ex-ploratory/ Explanatory design	Two-phase design
Description Both, quantitative and qualitative data are collected and analyzed in separate procedures. *Aim* Cross-validate or cor-roborate findings of the two approaches.		Concurrent two-studies design	Triangula-tion model	Concurrent design/ Nested design	Triangulation design/ Nested design	Dominant less-dominant design
Description Quantitative data is analyzed using qualitative procedures. *Aim* Investigate and under-stand the problem in depth, derive new theo-retical insights.	Integrated designs	Integrated elaboration design	Elaboration model	Combina-tion design	Trans-formative design	Mixed-methodo-logy design
Description Qualitative material is collected and trans-formed into categorical data for further quanti-tative analysis. *Aim* Derive both theory and generalizable results.		Integrated generaliza-tion design	Generaliza-tion model			

The mixed model method that will be used for this research study follows the integrated design approach. This means that there is one data set that will be analyzed both hermeneutically and statistically (Bazeley, 2003). Specifically, the generalization design defined by Mayring (2001) will be applied since the data starts as qualitative text information and is transformed by a systematic coding process into quantitative nominal numerical data (Mertens, 2005). This generalization model has been applied to organizational studies in many different areas of management research (Putnam & Jones, 1982), (Brett, Shapiro, & Lytle, 1998), (Weingart, Olekalns, & Smith, 2004). Since the TLS is considered a business system that is applied across an organization the research method needs to be selected to allow the researcher the ability to grasp and understand the problem fully. That is why the generalization integrated design model was selected for this research study.

Some limitations of the mixed model method is that data analysis is very time consuming since there are multiple analysis phases. That leads to another limitation, namely, that most researchers are trained in either quantitative or qualitative research methods, but to use the mixed model method the researcher must understand and apply both methods. The researcher must also consider the audience that the study will be presented to so that the analysis steps used are explained clearly between the qualitative and quantitative steps and that transition from one method to the other is understood.

The process for conducting the generalization design research follows the outline provided by Srnka and Koeszegi (2007). They have identified a five stage process that allows the researcher to explore the qualitative material inductively which is then systematically coded. Once this information is coded the data can then undergo

quantitative statistical analysis. Figure 3.2 illustrates this five stage process for analysis of the qualitative information.

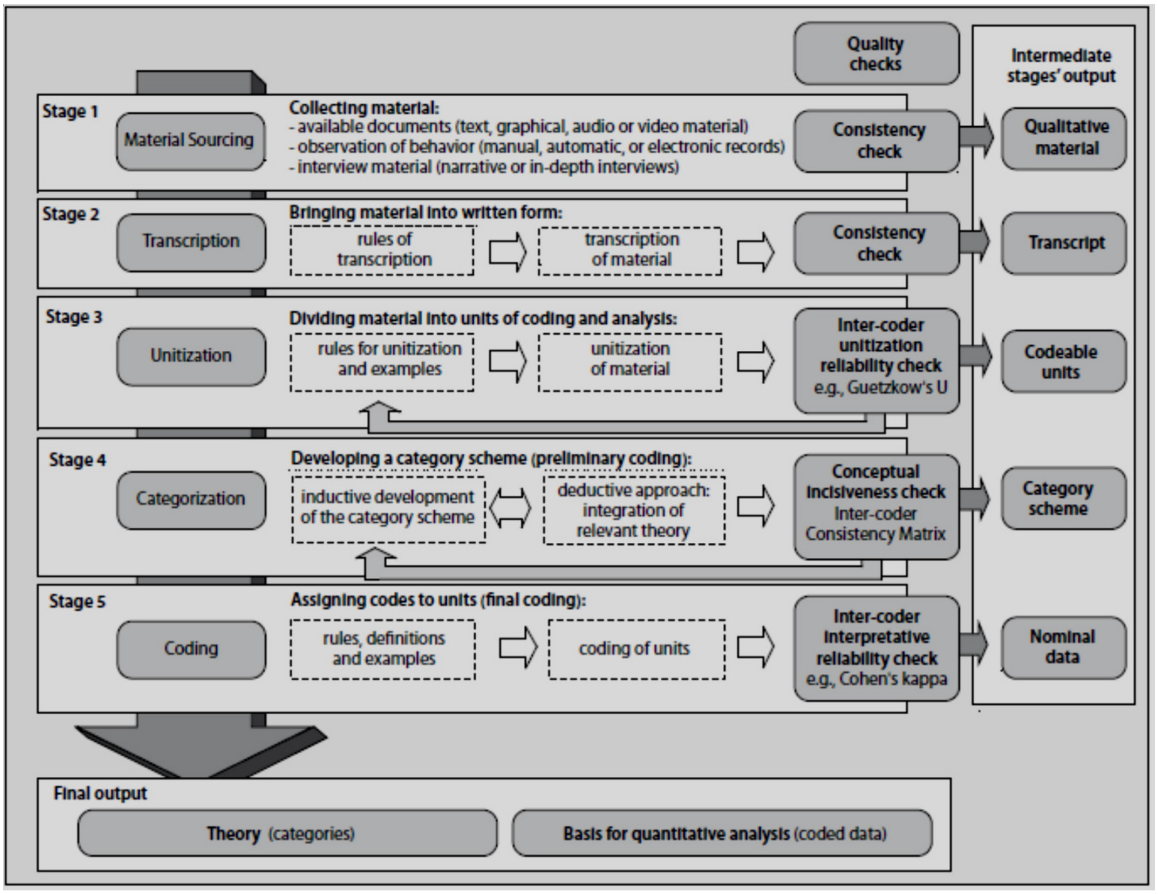

Figure 3.2: Qualitative Analysis Process (Source: Srnka & Koeszegi, 2007)

Following the five stage process the output of the qualitative information is transformed into nominal numerical categorical data. This data becomes the input for the quantitative statistical analysis. This data can be used for exploratory, descriptive, or hypothesis testing to further develop new theory (Srnka & Koeszegi, 2007). Figure 3.3 describes a three stage process to analyze the categorical data to develop new theory.

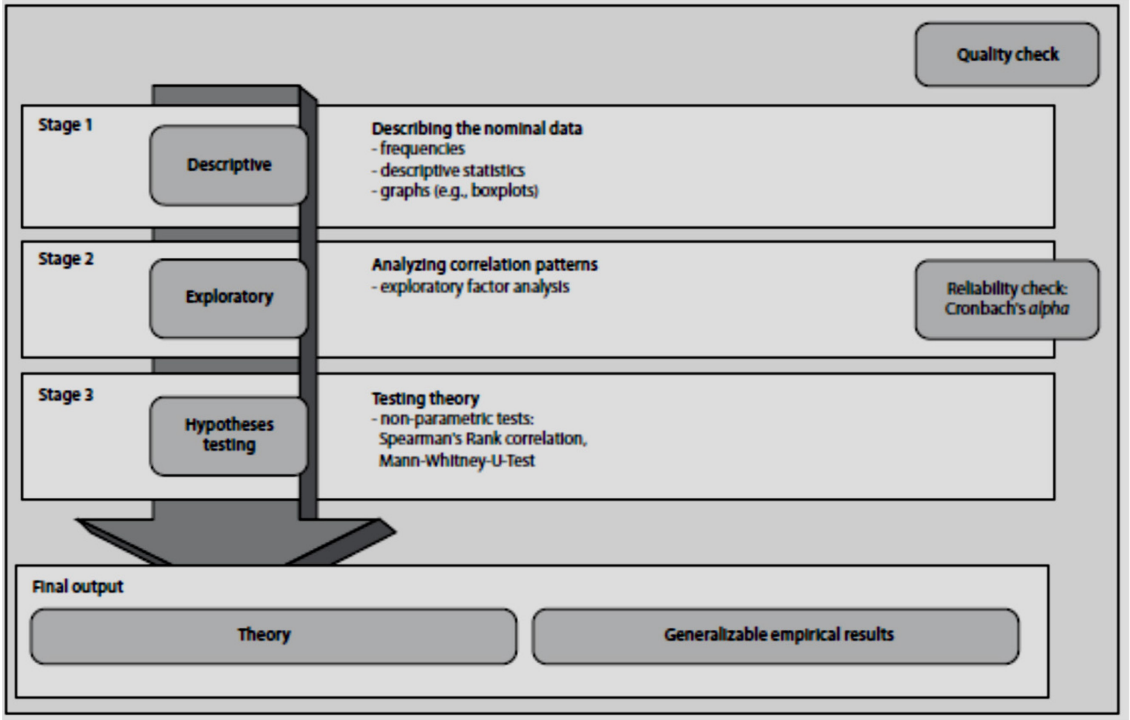

Figure 3.3: Quantitative Analysis Process (Source: Srnka & Koeszegi, 2007)

3.4 Data Collection & Analysis

Following the five stage process outlined in Figure 3.2, the material sourcing started with assessment questionnaires completed by 234 anonymous participants implementing a TLS. The questionnaire was a structured questionnaire with the questions identified in advance, using the same words throughout. The responses from the participants were open ended text where there no predefined answers provided. This structure allows for honest and open information from the respondents based on the current condition within their respective organizations. The questions are outlined below:

1. Leadership
    a. Explain management's role in nurturing lean behaviors/culture? Are these behaviors consistent across management?

b. What training or reinforcement exists to maintain a "one voice" system among the management team?

2. Operations Environment
    a. In terms of resources:
        i. How clear are people's roles?
        ii. Is the training for these roles clearly defined so that the role is maintained when the people that fill them change?
        iii. How do these roles support a Problem Solving environment?
    b. For daily operations:
        i. Are standards clearly in place for quality, time, and cost? Are these standards linked to the customer's demand/needs?
        ii. Is there a clear separation of normal and abnormal work? Whose role is it to perform the abnormal work?
    c. Continuous Improvement
        i. How is visual management used to identify problems for continuous improvement activities?
        ii. What key performance indicators are used for continuous improvement?
        iii. Is there a consistent problem solving method used in all continuous improvement activities?
    d. In terms of process flow:
        i. How connected is the physical flow?
        ii. What method is utilized to connect/manage the information flow?
3. Culture
    a. Creating a positive work environment
        i. Is there trust in management? How is it measured?
        ii. What opportunities exist for people throughout the organization to participate in improvement activities?
        iii. What outlets exist for people development?
        iv. How is team spirit gauged?
    b. People side—At all levels within the organization (executive, management, operations (non-exempt)) how are your competencies supportive of a lean culture? Provide details in terms of the following:
        i. Performance Evaluation
        ii. Management development
        iii. Compensation
        iv. Succession planning
    c. Problem solving practices at all levels (executive, management, operations)
        i. What systematic problem solving methods are used?
        ii. Is it a safe environment for problem solving?
        iii. How are problems prioritized to work on first?
        iv. What activities for engagement/recognition exist for problem solving?

In the second stage of analysis the assessment questionnaires were then transcribed into a common format (PDF) and incomplete questionnaires were removed from the pool of responses. This left the researcher with 213 complete questionnaires to use for analysis which is more than adequate for an inductive mixed model research study. Creswell (1998) and Morse (1994) state that when using a grounded theory methodology 30-50 data sources are a sufficient sample size.

The next stage for the analysis of the qualitative information was unitization. This is defined by Srnka as "choosing the unit of analysis and dividing the material into coding units" (Srnka & Koeszegi, 2007). There can be different approaches researchers take to unitize their documents looking words, sentences, or text chucks depending on the needs of the research question (Simons, 1993). For this research study it was important to look at the complete document in order to understand the full context. However, with 213 separate documents to analyze, and each document ranging from 700 to 1500 words it was too time consuming to analyze each document manually. So, for this stage the researcher used text mining software to unitize each word across each document to build a term frequency and document frequency matrix (TFDF). The complete TFDF matrix is shown in Appendix D. This was used to statistically determine which words (concepts) were most important across the document collection. The output from this TFDF matrix was used as input into stage 4: Categorization. In this stage the goal is to reduce the data down to the main dominant and relevant themes for deeper analysis (Srnka & Koeszegi, 2007). This process resulted in seven dominant themes shown in Table 3.2.

Table 3.2: Categorization Themes

KEY	
X1	One Problem solving Method Defined
X2	Multiple Problem solving Methods Defined
X3	Standard Work documented
X4	Training Method Defined
X5	Roles Defined
X6	Normal & Abnormal Work Separate
Y1	Problem Solving Outlets

The final stage of the qualitative information analysis was coding the information. This stage transformed the qualitative information into a categorical binary matrix based on the presents of the identified themes in each one of the participants' documents. Table 3.3 shows an example for a subset of the surveys.

Table 3.3: Categorical Binary Matrix

Survey #	Y1	X1	X2	X3	X4	X5	X6
1	1	1	0	1	1	1	1
2	1	0	1	0	0	0	0
3	1	1	0	1	0	0	0
4	1	0	0	0	1	0	0
5	1	0	1	0	0	0	0
6	1	1	0	0	0	0	0
7	1	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	1	0	1	0	0	1	0
10	1	0	0	1	0	1	0
11	1	1	0	1	0	0	0
12	1	0	1	1	1	1	0
13	1	1	0	1	1	0	0
14	0	0	0	0	0	0	0
15	1	0	1	0	1	1	0
16	1	0	0	0	0	0	0
17	0	0	0	0	0	0	0
18	1	1	0	1	0	0	0
19	0	0	0	1	1	0	0
20	1	0	0	0	0	1	0
21	1	1	0	0	0	0	1
22	1	0	0	0	0	0	0
23	1	0	1	1	0	0	0
24	1	1	0	1	0	0	0
25	0	0	0	0	0	0	0

The data in Table 3.3 was then analyzed quantitatively used logistic regression to understand which of the potential predictor variables, X1 through X6, had an impact on the dependent variable, Y1. This analysis is detailed in the next chapter, and the results of the models evaluated are explained.

CHAPTER 4: RESULTS

4.1 Introduction

This chapter details the results of the data analysis defined by the method described in the previous chapter. The first section details the background of the data that was used for this research, explaining the source of the data. In Section 4.3 the data is analyzed qualitatively using text analysis software to identify themes, and then coded and transformed into a binary matrix. Section 4.4 explains the quantitative data analysis conducted on the binary matrix through the use of logistic binary regression to identify significant variables. This section also details the various models tested using the logistic binary regression framework and identifies the model with independent variables "1 Method of Problem Solving" and "Documented Standard Work" as the best fit for the dependent variable of "Outlets to use Problem Solving".

During this research study, two computer programs were used to analyze the data. For the qualitative analysis of the textual data, the program RapidMiner was used to determine word count frequencies and document count frequencies. For the quantitative analysis performed on the binary matrix, the analytics software Statistical Analysis System (SAS) was used to perform the logistic binary regression and output the statistic results of each model.

4.2 Review of the Data

The data used for this study was obtained through anonymous company assessment surveys from individuals attempting to implement the TLS as defined in Chapter 1 of this

dissertation. The company assessments covered questions related to company direction for the TLS, clarity of roles and responsibilities, documentation of standards, methods for continuous improvement/problem solving, and organizational culture. The responses of the assessments were open-ended text; meaning there were no predefined responses available to choose from for respondents' answers. Instead, respondents were provided open spaces to explain the current situation within their organization as it related to the questions. The text data obtained from the respondents ranged from 1,000 to 4,200 words per assessment with most assessments consisting of approximately 2,000 words. The template respondents were provided is shown in Appendix B along with samples of completed assessments.

The assessments were collected over a three year period, and a total of 233 respondents provided information. The assessments received came from a variety of organizations in manufacturing, healthcare, and service; however, since the assessments were anonymous the breakout of this information isn't known. For this study, it is assumed that the TLS can be applied the same to any organization or function where the focus is to create a system where people can problem solve to make their work environment better.

4.3 Qualitative Data Analysis and Descriptive Statistics

The first step taken to analyze the data was to uncover themes within the assessments as a whole through qualitative data analysis. The 233 assessments were taken as a text corpus and entered into the data science software program RapidMiner to perform text mining. Screen-shots of the processes used within RapidMiner are shown in Figures

4.1 and 4.2. Figure 4.1 shows the "Process Documents from Files" operator being used to read in the assessment files to the RapidMiner software and output the different words used across all of the documents. Figure 4.2 shows the sub-processes that were used within the "Process Documents from Files" operator. The first sub-process was the Transform Cases step which turns all letters within the documents into lower cases so that the program doesn't consider words as different if one is capitalized and one is not. For example, if the Transform Cases process wasn't used, the terms "lean" and "Lean" would be considered different terms and counted separate which would take away from seeing the full importance of the term within the text corpus. The second sub-process is the Tokenize step which uses the spaces, commas, and punctuation between words to understand the start and end point for each term. The next sub-process is to Filter Stopwords which removes the most common words in natural language. For example, the words *and, the, is, that, etc*. provide no meaning for uncovering themes across the corpus but would rank highest of the terms within the documents if the Term Frequencies (TF) or Document Frequencies (DF) were examined. Since these words add no value in the context of themes within the corpus the Filter Stopwords process removes them from the corpus before the output. The forth sub-process is to Filter Tokens by Length. This process simply allows the researcher to put boundaries on the length of terms (tokens) within each document within the corpus. This allows for the removal of single letter words like *a* and *I* as well as typos where words have missed spaces between them. The final sub-process is the Generate n-Grams which allow the researcher to see when two or more words (tokens) happen in sequence within documents. This is an important process because it will count the occurrence within the documents of token phrases such as "problem solving" as a single term within the TF and

DF outputs. If this process was not included, then the program would only count "problem" and "solving" separately and the researcher would never know the frequency of how often the two words were used together in context of the document. The final output of the RapidMiner process created a table that identified the most common tokens (words and phrases) used across all documents within the text corpus. This complete table is shown in Appendix D.

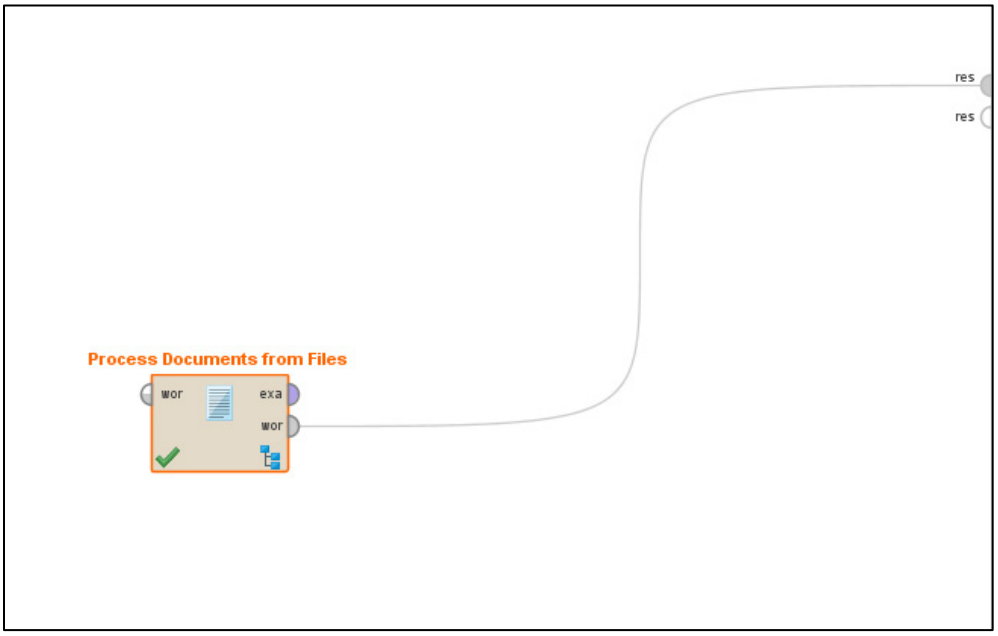

Figure 4.1: Process Documents for Files RapidMiner Process

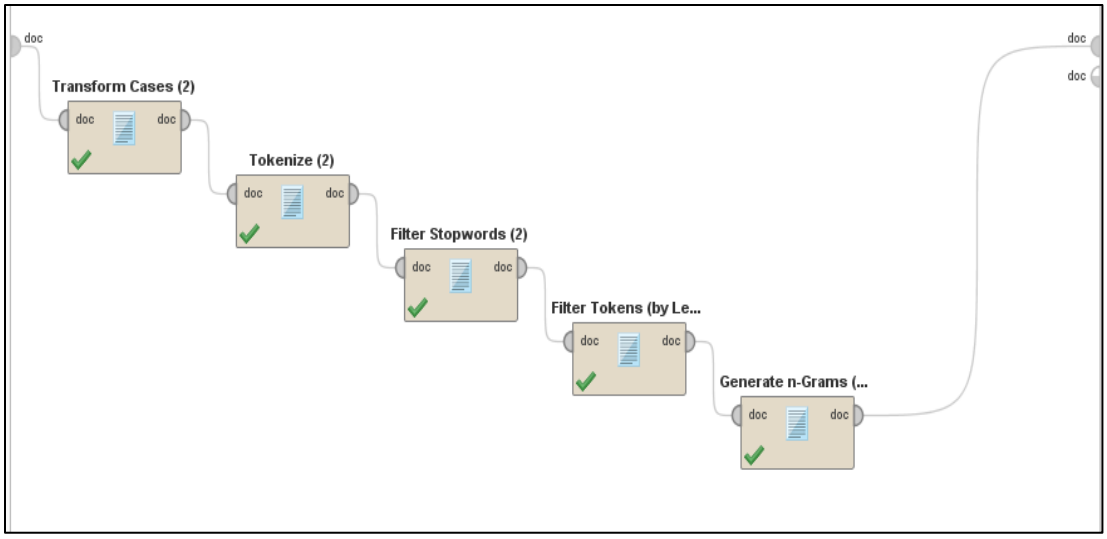

Figure 4.2: Sub-Processes for RapidMiner Process

The next step in the qualitative analysis was to examine the RapidMiner output to uncover the major themes within the text corpus. To determine the most dominant themes across the texts the RapidMiner output was sorted by the Total Occurrences and the Document Occurrences of each token. The complete RapidMiner output is shown in Appendix D and shows that the text corpus has a total of 202 reoccurring tokens. Those tokens were then grouped into categories to see the dominant themes across the text corpus. Tables 4.1 through 4.5 show the dominant themes identified across the text corpus as: Problem Solving, Standardization, Training, Roles & Responsibilities, and the Separation of Normal & Abnormal work. Another dominant theme that was uncovered during this analysis was Company Culture; however, due to the broadness of this category relative to the data obtained this factor was not investigated further in this study.

Table 4.1: Problem Solving Themes within Text Corpus

Problem Solving Themes			
Word	**Total Occurrences**	**Document Occurrences**	**Percentage of Documents**
problem	3613	233	100%
solving	3157	233	100%
problem_solving	3073	233	100%
improvement	1918	233	100%
continuous	1213	232	99.6%
continuous_improvement	1166	232	99.6%
problems	1111	231	99.1%
improvement_activities	814	230	98.7%
participate	412	229	98.3%
systematic	376	229	98.3%
systematic_problem	340	229	98.3%
opportunities	557	228	97.9%
engagement	398	228	97.9%
participate_improvement	254	228	97.9%
prioritized	288	227	97.4%
opportunities_exist	241	227	97.4%
activities_engagement	234	227	97.4%
solving_practices	230	227	97.4%
solving_methods	259	226	97.0%
outlets	243	226	97.0%
engagement_recognition	240	226	97.0%
solving_method	330	225	96.6%
support_problem	279	225	96.6%
environment_problem	277	225	96.6%
solving_environment	268	225	96.6%
identify_problems	252	225	96.6%
consistent_problem	254	224	96.1%
problems_continuous	233	223	95.7%
problems_prioritized	250	222	95.3%
method_continuous	232	222	95.3%
solving_problem	252	208	89.3%
solving_problems	246	206	88.4%
events	231	99	42.5%

Table 4.2: Standardization Themes within Text Corpus

Standardization Themes			
Word	**Total Occurrences**	**Document Occurrences**	**Percentage of Documents**
process	1493	233	100%
standards	922	230	98.7%
defined	654	230	98.7%
consistent	717	229	98.3%
methods	355	229	98.3%
method	761	228	97.9%
clearly	665	228	97.9%
practices	325	228	97.9%
perform	366	226	97.0%
clearly_defined	342	226	97.0%
standards_linked	264	225	96.6%
standards_clearly	238	223	95.7%
quality_standards	269	217	93.1%
criteria_clear	401	201	86.3%
standard	562	172	73.8%

Table 4.3: Training Themes within Text Corpus

Training Themes			
Word	**Total Occurrences**	**Document Occurrences**	**Percentage of Documents**
training	1898	233	100%
development	1052	233	100%
training_reinforcement	237	224	96.1%
training_roles	247	223	95.7%
explanations	1653	214	91.8%
develop	247	120	51.5%

Table 4.4: Roles & Responsibilities Themes within Text Corpus

Roles & Responsibilities Themes			
Word	**Total Occurrences**	**Document Occurrences**	**Percentage of Documents**
roles	1576	232	99.6%
levels	784	232	99.6%
roles_support	250	225	96.6%
roles_clearly	264	223	95.7%
people_roles	249	221	94.8%

Table 4.5: Separation of Normal & Abnormal Themes within Text Corpus

Separation of Normal & Abnormal Themes			
Word	**Total Occurrences**	**Document Occurrences**	**Percentage of Documents**
abnormal	909	232	99.6%
normal	470	231	99.1%
normal_abnormal	359	228	97.9%
separation	317	228	97.9%
separation_normal	278	227	97.4%
clear_separation	280	226	97.0%
perform_abnormal	251	223	95.7%

It was important to understand if the themes in Tables 4.1-4.5 were dominant across the texts to understand their significance; if the themes were not significant, then there would be no need to investigate the data further to understand the impacts these categories have on a TLS implementation. Since the initial text mining process did show that the above themes were important the final step in the qualitative analysis was to code the data based on the respondents' answers to each of the questions in the assessment. The coding was done by reading each of the assessments and identifying whether or not the respondent provided information detailing the presences of the themes associated with the key shown in Table 4.6 where X1 through X6 are the independent variables and Y1 the dependent variable under consideration.

Table 4.6: Key of Variable Names

KEY	
X1	One Problem solving Method Defined
X2	Multiple Problem solving Methods Defined
X3	Standard Work documented
X4	Training Method Defined
X5	Roles Defined
X6	Normal & Abnormal Work Separate
Y1	Problem Solving Outlets

Appendix E provides the complete output of the coding process for all of the assessments. A snapshot of this information is shown in Table 4.7. The information is coded as a binary matrix such that if the given variable has been identified as present within the organization, then the corresponding column for that survey will be coded as "1". If the variable is not present, then it is recorded as "0". The data within this binary matrix provided the input for the qualitative data analysis that is described in section 4.4.

Table 4.7: Sample of Coded Binary Matrix

Survey #	Y1	X1	X2	X3	X4	X5	X6
1	1	1	0	1	1	1	1
2	1	0	1	0	0	0	0
3	1	1	0	1	0	0	0
4	1	0	0	0	1	0	0
5	1	0	1	0	0	0	0
6	1	1	0	0	0	0	0
7	1	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	1	0	1	0	0	1	0
10	1	0	0	1	0	1	0
11	1	1	0	1	0	0	0
12	1	0	1	1	1	1	0
13	1	1	0	1	1	0	0
14	0	0	0	0	0	0	0
15	1	0	1	0	1	1	0
16	1	0	0	0	0	0	0
17	0	0	0	0	0	0	0
18	1	1	0	1	0	0	0
19	0	0	0	1	1	0	0
20	1	0	0	0	0	1	0
21	1	1	0	0	0	0	1
22	1	0	0	0	0	0	0
23	1	0	1	1	0	0	0
24	1	1	0	1	0	0	0
25	0	0	0	0	0	0	0

4.4 Quantitative Data Analysis with Binary Logistic Regression

The final stage of analysis for this research study was to perform logistic regression on the binary matrix as shown in Appendix E. This section will first provide the descriptive statistics for the dependent variable, Y1, and predictor variables, X1-X6. Then the correlation results for all predictor variables will be examined, and finally, the logistic regression results will be discussed. In this discussion the logistic regression model sets considering predictor variables X1-X6; predictor variables X1, X2, X3; predictor variables

X1 and X3; and predictor variables X2 and X3 will be reviewed. All of the statistical analysis for this part of the research was performed using the SAS 9.4 software package. The SAS program code for each analysis step is shown in Appendix F.

Tables 4.8-4.14 shows the SAS output for the frequency of non-existence ("0") and existence ("1") of the dependent variable Y1 and the predictor variables X1 through X6. The output data in Table 4.8 shows that for the dependent variable Y1 approximately 80% of respondents identified that their organizations have people engaged in using outlets for problem solving.

Table 4.8: Descriptive Statistics for Y1 Dependent Variable

Y1	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	44	20.66	44	20.66
1	169	79.34	213	100

For Tables 4.9 and 4.10 the data shows that when asked if their organizations provide standardized problem solving methodologies for people to use approximately 20% of the respondents said there is one standard problem solving method used at all levels (X1) and approximately 47% said that there are multiple defined problem solving methods (X2) which people within the organization can choose from to use when they attempt to perform problem solving on an issue. As a result, if X1 = 0 and X2 = 0 then the organization has identified no standard problem solving methodology for people to use when engaged in problem solving activities. For this data set, approximately 33% of respondents fell into that category.

Table 4.9: Descriptive Statistics for X1 Predictor Variable

X1	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	171	80.28	171	80.28
1	42	19.72	213	100

Table 4.10: Descriptive Statistics for X2 Predictor Variable

X2	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	114	53.52	114	53.52
1	99	46.48	213	100

Tables 4.11-4.14 show the breakdown of variables associated with the standardization of work processes. The variable X3 shows that only 39% of respondents have standard work documented for work processes. X4 shows that only 17% of respondents say that their organizations have defined training methods to train people on their job. Table 4.13 shows that only 22.5% have clear roles that define who are responsible to perform certain job tasks within the work environment. Finally, X6 identifies that only 10% of respondents have organizations that can highlight when processes are running outside of the standard condition. These factors, X3-X6 are considered important for the TLS because they all contribute to process standardization which is the foundation of TPS thinking described in Chapter 1.

Table 4.11: Descriptive Statistics for X3 Predictor Variable

X3	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	130	61.03	130	61.03
1	83	38.97	213	100

Table 4.12: Descriptive Statistics for X4 Predictor Variable

X4	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	177	83.1	177	83.1
1	36	16.9	213	100

Table 4.13: Descriptive Statistics for X5 Predictor Variable

X5	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	165	77.46	165	77.46
1	48	22.54	213	100

Table 4.14: Descriptive Statistics for X6 Predictor Variable

X6	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	192	90.14	192	90.14
1	21	9.86	213	100

The next step of analysis was to check the correlation between the predictor variables X1-X6. To understand the correlation between those variables the Pearson Correlation Coefficient was calculated using SAS. The results are shown below in Table 4.15 indicating the p-value and r (Pearson's Correlation) for each variable. For this

analysis the standard assumption of p-values > 0.05 to be insignificant, therefore the r value for those variables is assumed to be r = 0. The data in Table 4.15 shows that there is a moderate negative linear correlation between predictor variables X1- X2, and a weak positive linear correlation between X4-X5; as well as very weak positive linear correlations between variables X2- X4, X3-X4, and X4-X6.

Table 4.15: Correlation Matrix Results for X1-X6

Pearson Correlation Coefficients, N = 213 Prob > |r| under H0: Rho=0	X1	X2	X3	X4	X5	X6	
X1	1	-0.46184	0.03953	-0.0031	0.09984	0.07359	r
X1		<.0001	0.5661	0.9641	0.1464	0.285	p-value
X2	-0.46184	1	0.12397	0.13231	0.10567	0.00756	r
X2	<.0001		0.071	0.0538	0.1242	0.9127	p-value
X3	0.03953	0.12397	1	0.17909	0.02986	0.09097	r
X3	0.5661	0.071		0.0088	0.6648	0.186	p-value
X4	-0.0031	0.13231	0.17909	1	0.35642	0.18703	r
X4	0.9641	0.0538	0.0088		<.0001	0.0062	p-value
X5	0.09984	0.10567	0.02986	0.35642	1	0.01009	r
X5	0.1464	0.1242	0.6648	<.0001		0.8836	p-value
X6	0.07359	0.00756	0.09097	0.18703	0.01009	1	r
X6	0.285	0.9127	0.186	0.0062	0.8836		p-value

This correlation information is important to consider before performing the logistic regression because the interaction between those predictor variables could influence the results of the regression model.

The final qualitative analysis step was to perform logistic regression to understand if any of the possible predictor variables had a significant impact on the dependent variable, Y1. Tables 4.16 and 4.17 show the SAS output tables for the binary logistic regression when modeling all X1-X6 predictor variables. Table 4.16 shows that for each of the three

null hypothesis tests there are significant p-values; this indicates that at least one of the predictor variables (X1-X6) being modeled is statistically significant. Looking at the SAS output in Table 4.17 shows that the variables X1 and X2 are significant for the model based on the p-values < 0.05. However, the intercept and other predictor variables for this model are identified as insignificant.

Table 4.16: Null Hypothesis Testing for X1-X6

Testing Global Null Hypothesis: BETA=0			
Test	**Chi-Square**	**DF**	**Pr > ChiSq**
Likelihood Ratio	25.7477	6	0.0002
Score	24.4712	6	0.0004
Wald	20.4533	6	0.0023

Table 4.17: Analysis of Maximum Likelihood Estimates for X1-X6

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	0.3612	0.2723	1.7594	0.1847
X1	1	2.3988	0.7744	9.5941	0.002
X2	1	1.1472	0.3875	8.7658	0.0031
X3	1	0.6956	0.4076	2.9121	0.0879
X4	1	-0.7085	0.5514	1.6514	0.1988
X5	1	0.4212	0.5442	0.599	0.439
X6	1	-0.0389	0.6361	0.0037	0.9512

Based on the output for the model including all variables, X1-X6, and the seeing that some correlation exists between some of the variables the logistic regression is modeled again using only the X1, X2 and X3 variables. Table 4.18 displays the SAS output for the Null Hypothesis Testing for this model, and the results here indicated that since the p-values are significant for each test that at least one of the predictor variables being

modeled is statistically significant. Looking at the output in Table 4.19 shows that the X1 and X2 variables are significant based on the p-values < 0.05. When comparing this model output to the output for the modeling of X1-X6 (Table 4.17) the parameter estimates were very consistent for the intercept and X1-X3 variables.

Table 4.18: Null Hypothesis Testing for X1-X3

Testing Global Null Hypothesis: BETA=0			
Test	**Chi-Square**	**DF**	**Pr > ChiSq**
Likelihood Ratio	23.9906	3	<.0001
Score	22.9258	3	<.0001
Wald	19.3349	3	0.0002

Table 4.19: Analysis of Maximum Likelihood Estimates for X1-X3

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	0.3488	0.2635	1.752	0.1856
X1	1	2.4213	0.7667	9.9744	0.0016
X2	1	1.1238	0.3763	8.9181	0.0028
X3	1	0.6235	0.399	2.4418	0.1181

Since the X1 and X2 variables show a moderate negative correlation in Table 4.15, the next logistic regression model tested only the variables X1 and X3 to see if that had any impact on the their significance. The results for this model are shown in Tables 4.20 and 4.21. Table 4.20 once again shows that the Null Hypothesis Testing for this reduced model has significant p-values, so at least one of the variables is statistically significant. Examining Table 4.21 shows that the intercept, X1 and X3 are all significant for this model

since all p-values < 0.05. The variable X1 has been significant in all the models tested so far, but this is the first model to indicate that the intercept and X3 are significant.

Table 4.20: Null Hypothesis Testing for X1 & X3

Testing Global Null Hypothesis: BETA=0			
Test	**Chi-Square**	**DF**	**Pr > ChiSq**
Likelihood Ratio	14.7248	2	0.0006
Score	12.1537	2	0.0023
Wald	10.2599	2	0.0059

Table 4.21: Analysis of Maximum Likelihood Estimates for X1 & X3

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	0.8599	0.2108	16.638	<.0001
X1	1	1.8633	0.7486	6.1956	0.0128
X3	1	0.7894	0.3874	4.152	0.0416

The final reduced model that was tested included the X2 and X3 variables, and the model's results are shown in Tables 4.22 and 4.23. The Null Hypothesis Testing for this model shows that the p-values < 0.05 for all three tests; however, it should be noted that the p-values for this model were much larger than all the other models tested. In Table 4.23 it shows that the intercept is significant, with a p-value < 0.05 and the X3 variable right at the 0.05 cutoff. However, this was the first model containing X2 that showed that variable to be insignificant based on the p-value > 0.05.

Table 4.22: Null Hypothesis Testing for X2 & X3

Testing Global Null Hypothesis: BETA=0			
Test	**Chi-Square**	**DF**	**Pr > ChiSq**
Likelihood Ratio	7.4195	2	0.0245
Score	7.101	2	0.0287
Wald	6.8287	2	0.0329

Table 4.23: Analysis of Maximum Likelihood Estimates for X2 & X3

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	0.8596	0.2377	13.0806	0.0003
X2	1	0.5741	0.3577	2.577	0.1084
X3	1	0.738	0.3848	3.6789	0.0551

In order to make a selection of which model to use, the Model Fit Statistics were reviewed for each of the four models tested. The results are shown in Tables 4.24-4.27. Comparing the AIC and SC numbers for Tables 4.24 and 4.25 show that the nested X1-X3 model is an improvement compared to the model including X1-X6 variables. This is due in large part to the simplification for the X1-X3 model that no longer considered the insignificant variables of X4-X6. Using the X1-X3 model as the reference model, now the two remaining models of X1 & X3 and X2 & X3 will be compared to the reference. Looking at Tables 4.26 and 4.27 and comparing the AIC and SC numbers back to the reference model numbers in Table 4.25 shows that the increase in the SC criterion is small for the X1 & X3 but rather large for the X2 & X3 model. Therefore, since the X1 & X3 model is the simplest model tested, and the fit statistics match well to the reference model, this would be the suggested model to use for further analysis.

Table 4.24: Model Fit Statistics for X1-X6

Model Fit Statistics		
Criterion	**Intercept Only**	**Intercept and Covariates**
AIC	218.996	205.248
SC	222.357	228.777
-2 Log L	216.996	191.248

Table 4.25: Model Fit Statistics for X1-X3

Model Fit Statistics		
Criterion	**Intercept Only**	**Intercept and Covariates**
AIC	218.996	201.005
SC	222.357	214.451
-2 Log L	216.996	193.005

Table 4.26: Model Fit Statistics for X1 & X3

Model Fit Statistics		
Criterion	**Intercept Only**	**Intercept and Covariates**
AIC	218.996	208.271
SC	222.357	218.355
-2 Log L	216.996	202.271

Table 4.27: Model Fit Statistics for X2 & X3

Model Fit Statistics		
Criterion	**Intercept Only**	**Intercept and Covariates**
AIC	218.996	215.577
SC	222.357	225.66
-2 Log L	216.996	209.577

Referring back to Table 4.21 will provide the parameter estimates of the coefficients of the intercept, X1 and X3 variables for the logistic regression equation. This equation is shown below in Figure 4.3. Solving for *P* (Figure 4.4) gives the probability of having Y1=1 for the given X1 and X3. The results of the equation in Figure 4.4 are shown in Table 4.28. Note that since both X1 and X3 were binary variables, the results of Figure 4.2 had only four possible outcomes. The results show that when each variable was increased, either independently or together, there was an increase in the probability of Y1.

$$log_e\left[\frac{P}{1-P}\right] = 0.8599 + 1.8633x_1 + 0.7894x_3$$

Figure 4.3: Logistic Regression Equation for X1 and X3

$$P = \frac{e^{0.8599+1.8633x_1+0.7894x_3}}{1-e^{0.8599+1.8633x_1+0.7894x_3}}$$

Figure 4.4: Probability Equation for X1 and X3

Table 4.28: Probability of Y1 Given X1 & X3

x_1	x_3	Probability $Y_1 = 1$
0	0	0.702639761
0	1	0.838796421
1	0	0.938381822
1	1	0.971044159

4.5 Summary

In this chapter, the results of the data transformation and analysis, developed in Chapter three, were presented. The results of four logistic regression models were shown to determine if any of the proposed predictor variables had any relationship to the dependent variable. In the next chapter, the findings will be discussed in relation to the original research questions and overall conclusions presented. The limitations of this research and suggestions for future study will also be explored.

CHAPTER 5: CONCLUSIONS AND DISCUSSION

5.1 Introduction

This chapter provides a summary of this research study. The results and findings are discussed in relation to the initial research questions posed at the beginning of this dissertation; the contributions of the research highlighted, as well as, the limitations; and finally conclusions with areas for suggested future work on the topic.

The chapter is divided into five sections. Following the introduction, Section 5.2 restates the initial hypothesis statements and discusses the findings to explain if the hypothesis were supported or not. Section 5.3 describes contributions of this research, and Section 5.4 the limitations. In Section 5.5 recommendations for future work are outlined.

5.2 Summary of Findings

In Chapter One the motivation of this research study set out to understand how focusing on the elements of Hitozukuri allows organizations to improve in the application of Monozukuri by creating a TLS; instead of simply applying lean tools to temporary improve results. The objective was to develop a model to identify which factors contribute to creating an organization that engaged in problem solving. Specifically, the research study was focused on understanding if the following hypotheses hold true based on the developed model:

H_1: The use of standard job training methods for job tasks within an organization will have no impact on the engagement of people participating in problem solving activities.

H_2: The number of standard problem solving methods used within an organization will have no impact on the engagement of people participating in problem solving activities.

Based on the results from the various logistic regression models tested and detailed in Chapter 4 the hypothesis H_1 is supported. In all models tested the variable for a defined training method, X4, was identified as insignificant with p-values > 0.05. This means that for the data for this research study shows that, indeed, having a defined (standard) job training method will have no impact on engagement of problem solving activities. However, it should be noted that for the reduced model selected that having standard work documented, X3, was a predictor variable for engagement of problem solving activities. Referencing the correlation matrix in Table 4.15, it showed that a weak positive linear relationship existed between variables X3 and X4. Since the topics of standard work and job training are closely related in practice, which the correlation data also supports, then it is possible that the questions were not clear enough to the participants that provided information.

With respect to second hypothesis the results of the logistic regression proved that H_2 did not hold true. Referencing the output of the logistic regression model considering predictor variables X1-X3 in Appendix G the SAS results show that the odds ratios for those variables. For this model both X1 and X3 had p-values < 0.05 so they were considered significant. The odds ratio for X1 showed that at organization using a single problem solving method was 11 times more likely to have people engaged in problem solving activities than an organization with no defined problem solving methodology. In terms of the X2 variable for the same logistic regression model the odds ratio showed that

an organization with two or more problem solving methodologies was 3 times more likely to have people engaged in problem solving activities than an organization with no defined problem solving methodology. Since both variables, X1 and X2, showed an improved likelihood of engagement in problem solving activities to organizations with no standard problem solving method identified, it is safe to say that the null hypothesis H_2 does not hold true. Based on the results of the odds ratios being significantly different between X1 and X2, then it has been shown that organizations which focus on adopting a single problem solving methodology can be more successful in having people engage in problem solving activities than those that have two or more problem solving methods.

5.3 Contributions

In chapter 3, a methodology was developed which used principles of data mining identify core themes across over 200 individuals applying the TLS within their organizations. The information was then coded and transformed into categories which were then analyzed statistically through logistic regression. This dissertation tested four logistic regression models to identify factors that connect elements of Hitozukuri and Monozukuri to successful implementation. At the heart of the TLS is creating an environment where people throughout the organization can use problem solving to learn and improve their work. The regression analysis showed that those organizations that focus on providing a strong foundation, in terms of standard work practices and one system of problem solving tend to create better environments for people to engage in problem solving activities. As more and more organizations around the world adopt the principles of TPS, and continue to struggle to sustain those practices it becomes more important to understand

what factors contribute to a successful implementation. This work has shown that organizations that focus on developing the Hitozukuri process first will be more successful at engaging employees in improving results through Monozukuri.

5.4 Limitations

The information used for this dissertation came from a consistent population who were focused on applying TPS in the TLS framework. Further study is needed to see if these findings apply to all organizations adopting the broader ideas of lean. To simply the analysis of the initial text information the resultant transformed matrix used binary coding for the categorical variables. The binary matrix allows for high-level relationships to be established, but more detail within the categories to get a rich understanding of those connections between the dependent and predictor variables. The information which was analyzed came from self-assessments across many different organizations so that results were least biased and general against a single company's success; however, since the information was obtained by anonymous self-assessment it was not possible to verify the current condition on-site at the organization.

5.5 Future Work

An initial framework connecting elements of Hitozukuri and Monozukuri has been established in this dissertation; however, many areas for future research exist to help expand the knowledge on TPS implementation. Some of these suggested areas are, as follows:

1. Apply the model to organizations applying lean outside of the TLS framework.
2. More detailed model to understand if the type of problem solving method used impacts engagement of work force.
3. Model to understand if the type of industry changes the dominant factors for success.
4. Study the types of job instruction methods in use to understand if that impacts the standardization and stability of processes.

APPENDIX A: TOYOTA PRODUCTION SYSTEM (TPS) TERMINOLOGY

This reference guide explains some of the special terms used on a daily basis at jobsites at Toyota Motor Corporation. It is our hope that this glossary of special terms will be of use to anyone wishing to further their understanding of the Toyota Production System.

Definitions obtain to create this book are from the following sources:

1. Toyota Motor Manufacturing, TMMK, Georgetown, 2007 (Toyota Production System Terms)
2. TPS Glossary, Toyota (Hand Book)
3. University of Kentucky, Center for Manufacturing, Lean Systems Group (2008 ©)

TERM	DEFINITION
Andon	A type of visual control that displays the current state of work (i.e., abnormal conditions, work instructions, and job progress information). It is one of the main tools of Jidoka. Often in the form of an electrical board which lights up to show at a glance the current state of work operations. Andon boards allow speedy corrective action to be taken by supervisors when a problem arises. Besides indicating abnormal situations, some Andons provide work instructions (such as quality checks, change of cutting tools and
Continuous Flow Processing	One of the three basic requirements of Just-In-Time. This means eliminating the stagnation of work in and between processes and carrying out one-piece-at-a time production.
Cycle Time	The total amount of time required for a worker to complete one cycle of his entire job process, including manual working time and walking time.
Fill-Up System	This is the system whereby preceding production processes keep a minimum inventory of finished parts, and produce only enough to replace, or fill-up those parts withdrawn by the following process.

Five "whys"	The so-called 5Ws and 1 H (who, what, where, when why and how) are used in analyzing production processes. To search for the true cause of problems, moreover, instead of asking "why" once, it is repeated five times.
Flexible Manpower Line	This means preparing a production line so that it can meet changing production requirements with any number of workers without lowering productivity. In contrast, a fixed-manpower line is one which always requires a fixed number of workers and no upward or downward adjustment can be made in it to meet changes in production demand.
Four S's	The four S's refer to the corresponding Japanese and English terms of Seiri-Sifting, Seiton-Sorting, Seiso-Sweeping, and Seiketsu-Spick and Span. Collectively they mean the maintaining of an orderly, clean and efficient working environment. Sometimes a fifth S in Japanese is added: Shitsuke indicating worksite discipline.
Frequent Conveyance	This refers to increasing the delivery frequency of parts in order to keep the inventory at each process to a minimum. To do this without lowering the load efficiency of vehicles (i.e. without increasing the total runs made by all vehicles) calls for mixed loading.
Genchi Genbutsu	Means go and see for yourself. Go see the problem. This is the belief that practical experience is valued over theoretical knowledge. You must see the problem to know the problem. *Get your boots on; common phrase used at TMMK.

Hoshin Kanri	Goals (with targets) and means for achieving it to address business priorities to move the organization to a new level of performance; variable from year-to-year; could also be multi-year; and is developed by executive management.
Jidoka	Jidoka along with Just-In-Time, is one of the two main pillars of the Toyota Production System. It refers to the ability of production lines to be stopped in the event of such problems as equipment malfunctions, quality problems or work being late either by machines which have the ability to sense abnormalities or by workers who push a line-stop button. Preventing in this way the passing on defects, reoccurrence prevention becomes simpler as abnormalities become more obvious making it possible to "build in quality at the production process". At the same time, since defects are prevented automatically, inspectors become unnecessary, which in turn results in significant labor savings.
Jishuken	Management driven kaizen activity where management members identify areas in need of continuous improvement and spread information through the organization to stimulate kaizen activity.
Just-In-Time	One of the two pillars of the Toyota Production System, Just-In-Time refers to the manufacturing and conveyance of only what is needed, in the amount needed. This enhances efficiency and enables quick responses to change. Just-In-time presupposes Leveled Production (Heijunka) and is build upon the three basic operating principles of the pull system, continuous flow processing and Takt Time.
Kaizen	Muda (non-value added) exist everywhere related to people, material and facilities, or the production set-up itself. Kaizen refers to the series of activities whereby instances of Muda are eliminated one by one at minimal cost, by workers pooling their wisdom and increasing efficiency in a timely manner. Kaizen activities typically empathize manual work operations rather than equipment. Also, Kaizen in not an activity to be performed by specialist, but can be – in fact should be – performed by all employees at each job site.

Kanban	This is a small signboard that is the key control tool for Just-in-Time production. Kanban serves: 1. Instruction for production and conveyance 2. A tool for visual control a. To check against over production b. To detect irregular processing speeds 3. A tool to perform kaizen The functional categories of Kanban are: 1. 1-card kanban (referred to as Production Kanban) 2. 2-card kanban (referred to as Withdrawal Kanban) 3. Part Specific kanban (used for single part family or grouping) 4. Route Specific kanban (used for mix production) 5. CONWIP (CONstant Work In Progress)
Kayoibako	Shipping Containers A strong container that can be used repeatedly for shipping products, parts, and so on. <u>Returnable</u> A term denoting containers made to be like kayoibako containers, i.e., returnable from the destination to the point of origin so as to be used repeatedly.
Kitting	A process that groups related items for a subsequent process to reduce or simplify lineside parts presentation for a Team Member.
Labor Savings	This means partial replacement of manual labor by machines. The savings on labor; however, is not to the extent of saving one unit of manpower.

Lead Time	A standard schedule. The time from placement of a product order to completion of product delivery.
Leveled Production	Heijunka is the overall leveling in the production schedule of the variety and volume of items produced in given time periods. This is a prerequisite for Just-in-Time production.
Manpower Savings	This means improving work procedures, machinery and equipment to free workers from particular jobs on a production line consisting of one or more workers.
Mixed-Load Conveyance	The term used when any plant transport vehicle is loaded with more than one type pf parts. Use of mixed loading makes it possible to increase frequency of delivery without lowering conveyance efficiency, i.e. without increasing the total number of deliveries. This in turn allows the amount of inventory kept at each process to be decreased. It also permits the delivery schedules to be more easily adjusted according to production changes.
Nemawashi	Preliminary work to involve other sections / departments in discussion to seek input, information and / or support for a proposal or change (policy, etc.) that would affect them. Also means to "prepare the soil."
Muda (non-value added)	Muda (non-value added – usually translated as waste) refers to those elements of production that add no value to the product and only raise costs: 1. Muda of Over-Production 2. Muda of Waiting 3. Muda of Conveyance 4. Muda in Processing 5. Muda in Inventory 6. Muda of Motion 7. Muda of Correction

Muda of Over Production	Just-In-Time production is an ironclad rule at Toyota and producing anything 1) earlier than needed or 2) in greater volumes than needed (as indicated by kanban or other indicators) results in excess inventory and is known as muda or over production. This muda often hides muda of waiting and muda of motion. It also leads to muda by an increase in the number of conveyance vehicles and pallets. Among the different kinds of muda, muda of over-production is the most serious.
Muda of Waiting	This refers to a situation where a worker who has been working according to a standardized work sequence finds himself unable to process to the next job. This often occurs due to the volume of work being low.
Muda in Conveyance	Conveyance itself is basically muda since it doesn't add any value to the product: the more conveyance per unit, the more the final product cost. This term refers to any conveyance above the minimum necessary to keep "Juts-In-Time" production operating smoothly – such as temporary unloading, load transfer, removal of small quantities, and movement from one spot to another.
Muda in Processing	Any work or processing that does not add value to the product and advance the production process or contribute to the precision or quality of the processed units is referred to as Muda in Processing.
Muda in Inventory	All of the inventory (materials in-process work and finished products) that derives from the process of production and conveyance.
Muda of Motion	Muda of Motion is any human movement in production that adds no value to the product.
Muda of Correction	This refers to the muda of producing defective items which must be repaired or disposed. Includes the regular processes which tend to make people less aware of the muda involved and therefore impair improvement.
Mura (unevenness)	This refers to the irregularities that sometimes happen in the production schedule or in the volume of parts or vehicles produced. Instead of remaining at set levels. Volume moves temporarily up or down. For workers, it refers to workloads which vary from the standard.

Muri (Overburden)	At the jobsite, this means giving too heavy a mental or physical burden to workers on the shop floor. For machinery, muri means trying to have equipment do more than its capability. Muda, mura and muri are known collectively as the 3 M's.
Multi-Process Handling	In Multi-Process Handling, one shop worker will move down a row of machines or equipment arranged in the order of the flow of production processes and will perform all necessary jobs within the Takt-Time.
Multi-Machine Handling	Multi-Machine Handling means that one shop worker will move along a group of machines or pieces of equipment and operate them to perform multiple jobs by himself. Those machines and equipment are grouped together because of the similarity of processes involved or similarity of the machines used.
Multi-Skill Development	In order to conduct one-piece-at-a-time production and multi-process handling, a shop worker must be able to perform many different jobs, operating diverse types of machinery and equipment. To accomplish this Toyota constantly endeavors to improve a worker's skills so that he can easily perform jobs outside his normal area of assignment following monthly Takt Time changes caused by production volume changes. Such a shop worker is multi-functional worker. (also called Shojinka) Takt-Time changes each month according to changes in the production schedule and with this change the area of assigned jobs changes also. This flexibility would not be possible without multi-function workers.
One-Piece-At-a-Time Production	This refers to the system of production in which only one part or one vehicle at a time is processed or assembled and sent along the production line to following processes
On-Line Set-Up	Of the many operations involved in set-up jobs, this refers to those operations which cannot be carried out without stopping the line or machines. Such operations include the actual changing of dies, cutting tools, jigs, etc. (Part of SMED – Single Minute Exchange of Die – Founder Shingo)

Off-Line Set Up	Those parts of the set-up operation which can be done without stopping the line or machinery. For example, the work of preparing and putting away dies, cutting tools and jigs.
Operational Availability	The time that a machine operates maintenance free as a percentage of the time during which it is switched on. This is equivalent time the reliability of equipment and its maintenance. The ideal condition is to have 100% operational availability during the time the machine is on to fill a Kanban order.
Operation Standards	The general name for standard procedure and conditions of all jobs. Operation standards ensure that standardized work is carried out correctly at each jobsite. The information is available at each jobsite on worksheets based on diagrams, quality check standards, QC process charts, safety standards, etc., and are aimed at achieving quality, quantity, cost and safety targets. Examples include, operation instruction sheets, quality check sheets, work standards sheets, etc…
Overflow Parts	These are parts that cannot fit on the racks along the production line or in other storage locations. They end up on the floor or otherwise temporarily stored nearby.
Pace Maker	This is a tool which informs the shop worker, foreman or supervisor whether work operations are ahead of or behind schedule.
Parts Withdrawal Kanban	This Kanban indicates the timing and quantity for a worker at one process to pick up a new supply of parts from a preceding process.
Pilot Production (Goushi)	A mass-production test, the stage prior to Gouguchi, in which goods are produced on the line in order to check for problems, inconveniences, and so forth.

Point of Occurrence (PoO)	A problem may not occur where it's first discovered. The point of occurrence is the physical location and step in the process where the problem actually occurs. It's located by following your process backwards from the point where the problem is discovered, step by step, checking each step until you no longer detect the presence of the problem. *That* physical location and step, is the point of occurrence.
Pokayoke	Also referred to as mistake proofing or error proofing. This refers to the low-cost, highly reliable devices or innovations that either detect abnormal situations before they occur at a production process, or once they occur will stop the machines or equipment and prevent the production of defective products. 1. Those which prevent errors by an operator and those which detect errors by an operator and give a warning 2. Those which detect defects in product and prevent further processing on them.
Production Leveling	Leveling the types and the volume of produced goods. A prerequisite for "just-in-time" production. (Also referred to as Heijunka)
Pull System	One of the three basic requirement of Just-In-Time. The Pull system refers to the system of manufacturing in which following production processes withdraw from proceeding processes the parts they need, when they need them, in the exact needed amount.
Production Instruction Kanban	This Kanban is used to order the start of production at each production jobsite.

Productivity	This is a measure used to evaluate production productivity. It is usually defined as follows: Productivity = $\frac{\text{Actual production (accepted units only)}}{\text{Number of workers x operating hours}} \text{ X } \frac{100}{\text{standard output per (man-hours) person per hour}}$ The above equation can cause problems, depending on how it is interpreted. The actual production should equal the number of units sold. When production and sales figure do not equal, even if apparent efficiency improvements are achieved, costs will not be reduced and overall productivity is considered to be poor.
Production Lead Time	This refers to the time it takes to provide one product from acceptance of order to shipment. It is defined as follows: Production lead time = A + B + C A : from order reception to beginning of work B: from beginning of work on raw materials to completing product (processing + non-processing time) C: from completion of first to last piece of one unit of conveyance.
Production Sequence Table	This is a table which shows the production sequence of different models on a mixed- model production line. Based on the ration of the "mix" of different models in the production plan, the order of producing different models follows a Heijunka or leveled pattern.
QC Process Chart	This chart lists the quality control (QC) items – standards, specifications, and characteristics of each process – for building quality in the production processes. It also includes the names of the supervisors and shop workers who are responsible for quality control and the QC methods used.
Quality Circles	A Team Member and Team Leader problem solving activity that emphasis human development while promoting worker involvement to improve work methods.

Set-Up Time	Set-Up time is divided into three elements as follows: 1. Off-Line Set-Up: time during which machine is not stopped 2. On-Line Set Up: time during which machine is stopped 3. Adjustment time: time after set-up is finished that machine is stopped to obtain necessary quality levels or resolve problems. Set-Up Time is the time it takes to change over from the production of one product to another, from the instant that the processing of the last component of one type is finished, to the production of the first good sample of the next type of component. It included all the time needed for changeover of the dies, cutting tools, etc.. Set-Up Time = On-Line Set Up Time + Adjustment Time
Sequential Parts Withdrawal	Once the production sequence for products and parts is decided, those products and parts must be picked up from preceding processes according to that sequence.
Signal Kanban	This is a Production Instruction Kanban used on a lot production line where different parts are processed and time is needed for changing from processing of one item to another. The Signal Kanban is a triangular shape, often referred to a "triangle Kanban."
Simultaneous-Start Time Study	This method used to discover problems on a production line or process. At a given signal, all shop workers start work beginning with the first job (the first job in the standardized work sequence.) When they have finished one cycle of jobs, another signal is given and they start work on the next cycle. Related to work flow synchronization and in confirming completed cycle.

Specification Manifest	This paper (also known as a build sheet) is attached to a vehicle or product giving instructions concerning the parts to be fitted to the vehicle or attached to the product. The instructions are expressed in codes. The advantage of this paper is that information and the product move along together.
Standardized Work	The Toyota Production System organizes all jobs around human motion and creates an efficient production sequence without muda. Work organized in such a way is called standardized work. It is made up of three elements: takt time, working sequence and standard in-process stock.
Standard In-Process Stock	One of the three elements making up standardized work this is the minimum quantity of parts always on-hand for processing in and between sub-processes. It allows the worker to do his job continuously in a set sequence of sub processes, repeating the same operation over and over on the same order.
Supplier Kanban	Supplier Kanban are attached to parts containers coming from suppliers. There Kanbans are basically used the same way as Withdrawal Kanbans.
Takt Time	Takt-Time is the time which should be taken to produce a component or one vehicle. It is calculated as follows: Takt Time = Total Daily Operating Time / Total Daily Production Requirement *Daily total operating time is figure on the basis of all machinery operating at 100% efficiency during regular working hours.
Takt Time (actual)	It is desirable that production targets be achieved within regular working hours and the word “Takt-Time” refers to work accomplished within regular hours. When it becomes necessary for operational purposes to calculate Takt Time for other than regular hours that Takt Time is called “Actual Takt Time.”

Tataki dai	Means to critique the status, the proposal and the problems, and not the person.
Toyota Production System	This is the manufacturing system developed by Toyota which pursues optimum streamlining throughout the entire system through the elimination of Muda (non- value added) and aims to build quality in at the manufacturing process while recognizing the principle of cost reduction. It also includes all the accompanying technology necessary to accomplish those aims. The two main sub-systems supporting the Toyota Production System are "Just-In- Time" and "Jidoka."
The Toyota Way (11 points)	As told by Atsuhi Niimi, President and CEO, Toyota Motor Manufacturing North America 1. Respect people 2. Be humble 3. Treat dealer and suppliers as partners and listen to what they say 4. Never become satisfied with the way things are because there is always an improvement waiting to happen 5. Go and see, don't read about it 6. Hold meetings to explore failures and find improvements, not to celebrate success 7. Be conservative and consistent 8. Be a good corporate citizen 9. Focus totally on customer so you can make money by earning their respect 10. Be fiercely competitive, because that is the best way to serve the customer 11. Reinvent money where you earned it

Toyota Way 2001	The Toyota Way (2001) is supported by two main pillars. They are "Continuous Improvement" and "Respect for People". We are never satisfied with where we are and always seek to improve our business by putting forth our best ideas and efforts. We respect people and believe the success of our business is created by individuals and good teamwork. All Toyota team members, at every level, are expected to use these two values in their daily work. <u>Continuous Improvement Pillar</u> Challenge – We form a long term vision ; meeting challenges with courage and creativity to realize our dreams. Kaizen – We improve our business operations continuously, always driving for innovation and evolution. Genchi Genbutsu – We practice Genchi Genbutsu… go to the source to find facts to make correct decisions, build consensus and achieve goals at our best speed. <u>Respect for People Pillar</u> Respect – We respect others, make every effort to understand each other, take responsibility and do our best to build mutual trust. Team Work – We stimulate personal and professional growth, share the opportunities for development and maximize individual and team performance.
Value Adding Work (Shigoto)	Shigoto is the Japanese work for "work" or "job", but at Toyota refers to any process that adds value to the product.
Visual Control	This is when a manager or supervisor can tell at a glance if production activities are proceeding normally or not.
Working Sequence	One of the three elements of standardized work. It refers to the sequence of operations in a single process which leads a floor worker to produce quality goods in the moist efficient way.
Yamazumi	Line balance chart used at the Team Leader and Group Leader level to make decisions regarding work allocation. (Also known as line balancing using classical industrial engineering techniques.)
Yokoten	Across everywhere. Plant related activities and / or countermeasures that are communicated plant wide and with other company affiliates.

APPENDIX B: SAMPLE OF ASSESSMENTS

1. Leadership

Assessment Criteria	Explanations & Examples
Explain management's role in nurturing lean behaviors/culture?	The main role of managers is to pursue their Kpis of the area (Promote Safety First, Quality and Production Targets) and these are reflected in the Focus Documents (like a HOSHIN) to keep the follow up & control. During the process to achieve their kpis at all levels of his area, try to promotes teamwork, development of the Team members, empowerment, continues improvement and the execution of another set of tools Operation System, that will help to achieve the targets. The manager always looks for the result, however he puts more emphasis on the process of achieving the results (try) & the reason of this, is because is the way we can establish a working system, be consistent, replicate good results replicate and improve where we have the failures.
Are these behaviors consistent across management?	The company has about two years implemented the Model (Operation System) and his Culture, but still is the process and therefore not all management behaves the same way. We can say that the company every day is more closer to achieve this and to involve all management on the synergy to promote the kind of behavior described. The company is based on his Model, internally feedback (between Team members) & training in order to promote this type of behaviors all levels.
What training or reinforcement exists to maintain a "one voice" system among the management team?	Through the Model (Operation System), Culture, way and structure of work. And is reinforced by their constant communication through daily and monthly meetings a long the company.

2. Operations Environment

A. In Terms of Resources:

Assessment Criteria	Explanations & Examples
How clear are people's roles?	We have most of the roles already defined and described, the problem is in the consistency of communication and in the training of these. On the roles described clearly the responsibilities and boundaries of each. *(Draw out the org roles and responsibilities for your department on another page using the template on the following page as an example)*
Is the training for these roles clearly defined so that the role is maintained when the people that fill them change?	Most roles are clear and are reviewed each year, in case if there are any changes in the scope. The opportunities that we have is the communication, training and follow up.
How do these roles support a Problem Solving environment?	Developing a "sense of belonging" & "empowerment" in their span of control, where each Team members is responsible for what happens in it. Where they are responsible to solve their problems and if they are out of reach, ask for support to the next level. Each span of control has his team work & resources. These teams are being trained in the methodology Problem Solving.

2. Operations Environment

B. For Daily Operations:

Assessment Criteria	Explanations & Examples
Are standards clearly in place for quality, time and cost?	All procedures are in place & also production kpis. We follow up Cost Kpis, but we don't put/show it on the floor. In order to show this we use the 4M Board & Daily Production Board.
Are these standards linked to the customer's demand/needs?	All procedures and objectives are linked to meet the demand and needs of the company & customer. And also are modified in the pursuit of continuous improvement.
Is there a clear separation of normal and abnormal work? Whose role is it to perform the abnormal work?	We are in the process of standardization & visual management implementation, but still do not have well identified that separation normal vs. abnormal. And on the areas that you can identify the situation, we don't react how we supposed to do it & the reason is the mind set, is where we need to reinforce.

2. Operations Environment

C. Continuous Improvement:

Assessment Criteria	Explanations & Examples
How is visual management used to identify problems for continuous improvement activities?	There is no doubt that every day we are better on visual management, across the all plant in the different processes. We have production boards where we show our gaps and continuous improvement projects. Where we have to reinforce is in reaction to problems, when we show the normal vs. abnormal.
What key performance indicators are used for continuous improvement?	The Kpis that we follow up are: 1) Safety, OSHA 2) Quality Rate, PPM´s & Rework 3) %OEE, Downtime , Set up time 4) %Delivery 5) Days of Inventory
Is there a consistent problem solving method used in all continuous improvement activities?	The method what we use across the all plant is the methodology "problem solving" (Toyota Way) and is recorded as a A3. Where we need to reinforce how to approach it during the process of solving the problem.

2. Operations Environment

D. In Terms of Process Flow:

Assessment Criteria	Explanations & Examples
How connected is the physical flow?	The material and process flow are defined and all production areas are connected by WIP. We can say that there is clear flow, however by high inventories (Iceberg effect) we lost sight or cover the problems. Basically have a push system between areas.
What method is utilized to connect/manage the information flow?	To manage all material & process flow we used the QAD (MRP) system & to reinforce and use on real time data we develop an system "Monitor", that helps to know the in puts, out puts & performance of the production lines.

1. Culture

A. Creating a Positive Work Environment

Assessment Criteria	Explanations & Examples
Is there trust in management? How is it measured?	• Yes, there is trust & every day you can perceived it that is growing. The way how is created is giving you responsibility & freedom in decision making. I can say that you can measured it two ways.... 1) Ever year the company make survey in all team members of the company, where is evaluated the commitment, workplace & trust. This survey is done by areas, with the ideas to have more clear each subject on each area. After this, you will have the results & make action plans to improve on each item. 2) Feedback +,-,+ : This apply only the managements, where the managers & engineers get together and have a conversation face to face (only 2 persons at the time), with objective to give feedback, 2 positive & 1 to improve. This technique create an environment of trust & better communication.
What opportunities exist for people throughout the organization to participate in improvement activities?	•Each team members have the opportunity to participate on a Kaizen Project. On each production area, we have Kaizen activities based on our bottlenecks & things to improve. On this process we take team members of all levels of the staff of the production area. And also we have an internal program along the whole plant "Incremental Innovation", where give the opportunity to all TM, to participate and share there's lesson learns, improvements, etc. And every year they give a recognition to the TM who participate with more project & those kaizen projects with economic impacts.
What outlets exist for people development?	• Every position have a career plan, where it shows all the training that the TM must go for his growth. Sometimes this plan is carried out for different reasons. But the company always gives the opportunity to give options for training. And also we have an internal technique, where each position must have the "PDT (Talent Develop Plan)". This shows also the training, the areas where you must work in order to earn more experience and show you the different paths that you can have according to your profile. And the results of all these, is to let you know what kind position you can be considered.
How is team spirit gauged?	• It is kind of difficult to measure the team spirit, my point of view, where you can know how it is your Team spirit & how is your Team Work, is when you have problems and how they are facing like a team. All these results & actions later you will see it on yearly survey of the work environment/workplace.

1. Culture

B. People Side--At all levels within the organization (executive, management, operations) how are your competencies supportive of a lean culture? Provide details in terms of the following areas:

Assessment Criteria	Explanations & Examples
Performance Evaluation	• The performance evaluation of each team members is measured with a interview from the coordinator. This interview is made each 3 months, where evaluate Safety, Commitment, Improvements & attitude. And the results helps us to give feedback & also to consider for the levels promotions of the TM. Also is important to mention, the key point to operate this, is to have the training, support & leadership of the coordinator. And the performance evaluation for management also is made by the Focus Document, where the coordinator follow up you KPI of your area.
Management Development	• The company use the Operation System, and some things is based it on TPS. Therefore the company is training all key positions in these practices with the intention of being able to deploy this culture throughout the entire plant. The company idea, is to follow up this practices on weekly forums.
Compensation	• We have process of compensation, of course depends on the country. And this is based on the performance of each Team members. For the Managements measure the KPIs from Focus documents (they also evaluate the process, not only the results) & for the operators we used the interview that we explain above. The frequency of evaluation is every 3 months.
Succession Planning	• Each position have or are on the search to define a replacement. The main idea of this, is to promote and always have a back up plan of each person; for those cases where the person has to go to a promotion or new project.

1. Culture

C. Problem Solving practices at all levels (executive, management, operations)

Assessment Criteria	Explanations & Examples
What systematic problem solving methods are used?	• For internal use, we have the standard to use Problem Solve Methodology, Toyota way. And how to document it is in A3 format. All are kaizen projects we present it, on the A3 format. And also we use other methods on those cases that the customer required (8D´s).
Is it a safe environment for problem solving?	• Yes, we have started an environments to encourage the use of the Problem solving methodology. This environments is created by training on all levels, forums to have, share & create kaizen activities. Problem Solving Methodology is part of the Operation System. And also the "Incremental Innovation Program", use this methodology to operate. In order to record all the project you need to show the A3 report.
How are problems prioritized to work on first?	• The company always prioritized the items likes this : 1. Safety First 2. Customer Quality 3. Internal Quality 4. Efficiency 5. Cost With this, is how we give direction where to focus & of course is important to mention, that on each subject we have the data to make the paretos and analysis where we have the most critical problem & with major impact.
What activities for engagement/recognition exist for problem solving?	• We have the "Incremental Innovation Program", where every year recognized the TM that participate with the numbers of projects & with the high impacts. And also in terms to recognized those TM that make a big efforts and have big impacts on their projects, they will show on the Monthly Communication meeting the project. Is important to mention that this meeting is all Plants & is presented by the Plant Manager.

1. Leadership

Assessment Criteria	Explanations & Examples
Explain management's role in nurturing lean behaviors/culture?	Management has committed the entire organization to Lean, sending teams from all 4 divisions. They have encouraged all divisions to share experiences and each division has its own Lean team. They have also facilitated every team to establish its own practices without any interference. We have their full support and they have expressed that this is how they want the corporation to carry itself.
Are these behaviors consistent across management?	Yes they are.
What training or reinforcement exists to maintain a "one voice" system among the management team?	Sending Employees to Lean Systems Training. Having 5S training. Investing in training for the Team Leaders. Problem Solving.

2. Operations Environment

A. In Terms of Resources:

Assessment Criteria	Explanations & Examples
How clear are people's roles?	We are in a period of transition(culture change), where we have started to define these roles and are holding individuals responsible to them *(Draw out the org roles and responsibilities for your department on another page using the template on the following page as an example)*
Is the training for these roles clearly defined so that the role is maintained when the people that fill them change?	Yes they are, until recently this has been changed before they were not and we are now training to the new defined roles and responsibilities.
How do these roles support a Problem Solving environment?	Currently it does very little to contribute.

2. Operations Environment

B. For Daily Operations:

Assessment Criteria	Explanations & Examples
Are standards clearly in place for quality, time and cost?	Yes, they are.
Are these standards linked to the customer's demand/needs?	Yes
Is there a clear separation of normal and abnormal work? Whose role is it to perform the abnormal work?	No there is not.

2. Operations Environment

C. Continuous Improvement:

Assessment Criteria	Explanations & Examples
How is visual management used to identify problems for continuous improvement activities?	We currently to not use any type of these to initiate continuous improvement activities.
What key performance indicators are used for continuous improvement?	We use Efficiency, Up-time and Scrap Percentage as indicators for continuous improvement.
Is there a consistent problem solving method used in all continuous improvement activities?	Yes

2. Operations Environment

D. In Terms of Process Flow:

Assessment Criteria	Explanations & Examples
How connected is the physical flow?	The flow is connected through a push system.
What method is utilized to connect/manage the information flow?	We use JIT and FIFO methods.

1. Culture

A. Creating a Positive Work Environment

Assessment Criteria	Explanations & Examples
Is there trust in management? How is it measured?	There is a renewed trust in management, whereas before it was non-existent. We know this now through employee surveys conducted by Human Resources.
What opportunities exist for people throughout the organization to participate in improvement activities?	We now have plenty of opportunities, for we now know that are more efficient when enabling and empowering our employees within our operations instead of dictating to them what needs to be done. We now include our employees when we problem solve.
What outlets exist for people development?	We have this class as one of the best examples for people development. We also have employees sent to AMA for training as well as with NADCA training.
How is team spirit gauged?	Through Monthly employee meetings, shift change meetings and as mentioned before we have evaluations conducted by HR.

1. Culture

B. People Side--At all levels within the organization (executive, management, operations) how are your competencies supportive of a lean culture? Provide details in terms of the following areas:

Assessment Criteria	Explanations & Examples
Performance Evaluation	We still need to work on this. We have a culture to only perform these on a once year basis. This does not contribute to a healthy assessment and evaluation.
Management Development	Not at this time
Compensation	We are a Union Shop and fixed increases are dictated by the Union Contract. However we have improved our pay scale with the reset of our hourly non-exempt employees.
Succession Planning	There is no plan at this time.

1. Culture

C. Problem Solving practices at all levels (executive, management, operations)

Assessment Criteria	Explanations & Examples
What systematic problem solving methods are used?	We currently use A3's
Is it a safe environment for problem solving?	Yes
How are problems prioritized to work on first?	They are prioritized by external or internal issues. We focus on the External first being that these are Customer driven.
What activities for engagement/recognition exist for problem solving?	We have round table, one on ones and we also have problem Solving sessions in the form of Corrective Actions.

1. Leadership

Assessment Criteria	Explanations & Examples
Explain management's role in nurturing lean behaviors/culture?	Management role currently is to provide training and exposure to a lean environment and communication of the direction we are wanting to go and the path to get there. Management is here to provide guidance and support to allow employees to feel empowered enough to make a change and improve there own working environment.
Are these behaviors consistent across management?	Currently there traits our fairly consistent amongst most of the key managers. There are some in the management group that will talk the talk but when it comes to it does not follow thru. There is inconsistency in empowering employees. They will do it on major projects where it is highly visible but on day to day actives revert back to controlling or telling what to do.
What training or reinforcement exists to maintain a "one voice" system among the management team?	We are currently doing in-house training on 5s, A3s, and other tools for the management group. Most of the key managers have now been to this training. There is also a lean implementation team consisting of some of the key managers to help track projects and the role out of lean model areas. During this meeting it is discussed what support is needed and the status of these areas.

2. Operations Environment

A. In Terms of Resources:

Assessment Criteria	Explanations & Examples
How clear are people's roles?	Peoples roles and responsibilities are currently in a constant flux. We have vague job descriptions where leaves a lot of wiggle room for who is suppose to do what. Things tend to fall on who can do things more then who is suppose to do things. Many times some of the people that have been there for longer then most are asked to do a lot just because some time in the past they have done it or have an idea how to do it. *(Draw out the org roles and responsibilities for your department on another page using the template on the following page as an example)*
Is the training for these roles clearly defined so that the role is maintained when the people that fill them change?	Each department has books that have all the WI, Procedures, and documents for the department. Most in the department do not know that these books exists. People are put in roles and jobs but are asked to do things just because they need to be done in the moment not because it is necessary there jobs. This causes a lot of confusion on who is suppose to do what. Also, it makes it difficult when hiring since our job descriptions don't necessary reflect what is needed and it is not communicated what is wanted so who we bring in might not fit what we want. Also hard to develop an onboarding plan / training plan due to the role is going to change due to current needs and future needs that are not known at the moment. We also like to have someone shadow someone for a little bit and then allow them to do the work. This causes issues due to the first person was probably trained the same way which might not be what they are hired to do.
How do these roles support a Problem Solving environment?	This has a negative impact to the problem solving environment because it is easy to say "it is not my Job" or "I am not responsible for that". Things then tend to get pushed to higher levels and the blame also goes up to figure things out. The environment allows people to run in these abnormal situations because we have done it before and/or people think they can't do anything about it. They have to be told what to do next.

2. Operations Environment

B. For Daily Operations:

Assessment Criteria	Explanations & Examples
Are standards clearly in place for quality, time and cost?	For production yes. For service departments budget exists, indirect standards exist for tooling PMs (ie on time delivery of parts). Timing for repairs or tooling readiness is not tracked but effect other metrics.
Are these standards linked to the customer's demand/needs?	Yes they are linked to quotes for production. The indirect standards for my department are linked to customer requirements. Also timing and cost linked back to our quotes to customer.
Is there a clear separation of normal and abnormal work? Whose role is it to perform the abnormal work?	Currently this is no separation for normal and abnormal work. This is mainly due to abnormal work is not clearly defined. Due to standards being not clear employees believe that everything is normal and just part of the job. Abnormal work within tool room will be separated into multiple areas abnormal for one role would be normal for another. Ie what a mold repair person finds abnormal a mold maker would be normal for there role and responsibility.

2. Operations Environment

C. Continuous Improvement:

Assessment Criteria	Explanations & Examples
How is visual management used to identify problems for continuous improvement activities?	Currently they are just being implemented. We have added a CI board where suggestion cards can be added and status of projects are tracked. This is currently a manual board in the middle of the plant and has only be active for 3 weeks. There is a plan once people are use to this board making it electronic that can be shared in multiple areas of the plant.
What key performance indicators are used for continuous improvement?	Depending on area KPI for production are identified but for other areas no real KPI are listed and easily accessible by the people. During management review these are talked about and reviewed but not with the people on the floor. The floor personnel don't have a good way to see how they are preforming.
Is there a consistent problem solving method used in all continuous improvement activities?	Not currently we are in practice of teaching the 8 step problem solving process using the A3 format. This is a new practice that have been being utilized with the floor personnel for the last 2 months. This is still new and just starting to role out to the employees.

2. Operations Environment

D. In Terms of Process Flow:

Assessment Criteria	Explanations & Examples
How connected is the physical flow?	Our process flow I all over the map. Where departments are located things move around the plant a lot. Within some of the service departments it is a little better but due current area constraints (need to eliminate unnecessary equipment) things are piled on top of each other and can't flow thru the process easily.
What method is utilized to connect/manage the information flow?	Currently generic process flow diagrams are used that does not have all the information necessary/ needed in connecting and managing the information flow. The Pflows are missing too much information.

1. Culture

A. Creating a Positive Work Environment

Assessment Criteria	Explanations & Examples
Is there trust in management? How is it measured?	Management is in the process of rebuilding trust in the organization. This is being done thru ample communication thru all employee meetings and other department specific meetings. It is currently being measured by quarterly employee satisfaction surveys and also general communication amongst the employees and management.
What opportunities exist for people throughout the organization to participate in improvement activities?	We have stated a CI board where any employee can give an CI idea. Also when model area projects are stated process maps and floor plan layouts are posted with markers for any employee to give there suggestions / angry clouds.
What outlets exist for people development?	We have multiple places that the company has partnered up with to give training to employees. This is lacking as most managers don't actively communicate to the employees what is available to them. The employees are waiting on management to send them and management is waiting on employees to show interests and follow up. Also there are multiple training sessions from person that have been to training to help within department but that employees are selected by management and not volunteers.
How is team spirit gauged?	Team spirit is gauged on contributions during times on training, employee meetings, and participation on process maps when posted. This is more of a gut feel.

1. Culture

B. People Side--At all levels within the organization (executive, management, operations) how are your competencies supportive of a lean culture? Provide details in terms of the following areas:

Assessment Criteria	Explanations & Examples
Performance Evaluation	Performance Evaluations currently are not supportive of a lean culture. It is still mostly a matter of opinion on how people are doing. As there is lacking clear roles and responsibilities for the different positions it is difficult to evaluate people fairly on there job as it is not clearly defined in a way that has clear expectations.
Management Development	Currently management have been going thru the lean training at UK. There have been multiple people sent in the management group to help support a lean culture. Small steps have been taken as we progress thru model areas. The core management team will all have been to this class now. We be looking at the next level of management and supervision training also.
Compensation	Still very much the old way of thinking. Not truly based on performance / awarded for engorging model behavior. Compensation comes as more standard rate increases. It is hard to justify otherwise as clear expectations and levels are not established.
Succession Planning	There is a little in the way of secession planning. There is younger personnel in key positions but without a development plan for them they do not grow or they learn by trial by fire. In some of the key support departments (toolroom & Maintenance …) but as the apprenticeship programs in the past not present and not initiative to teach the younger generation it is a concern that is talked about within management but action has not taken place to correct this.

1. Culture

C. Problem Solving practices at all levels (executive, management, operations)

Assessment Criteria	Explanations & Examples
What systematic problem solving methods are used?	We are in our initial stages of utilizing the A3 (8-step) problem solving method. Only a few people within the origination has been trained in this method and truly understand it.
Is it a safe environment for problem solving?	It has improved for the employees. Ideas and thoughts are welcomed. But there is still negativity in the sessions amongst ideas and how ideas are presented. People get defensive when something within there department is brought up. Also some that have gone thru the training and strictly look at keeping to possible causes during the root cause analysis step gets frustrated and negative to others that jump to solutions.
How are problems prioritized to work on first?	Depends on the problems. This is an area of confusion right now as a new member of corporate has started and comes with a lot of new technology that wants implemented on his perceived problems. This has undermined the more patented/planned improvements which they truly are and not actual problems. But, as for problems in general it is more the hot topic of who ever is around. The focus is missing and direction is lacking on priority. This is more left up to the person. One vision one goal is not there.
What activities for engagement/recognition exist for problem solving?	As we are doing the 8 step problem solving training we are doing it in groups. As part of the group is to lead this effort and are encouraged to involve others outside the group when needed. Things that have been done are process maps out on the floor to allow all employees from any level give opinions. Also, during all employee meetings the problem solving teams progress are communicated and team is recognized for there efforts.

1. Leadership

Assessment Criteria	Explanations & Examples
Explain management's role in nurturing lean behaviors/culture?	Management approval, operations performance analysis for department, problem solving. Analyze KPI & Set target, foster discipline to follow the problem solving culture.
Are these behaviors consistent across management?	Engineering is involved with problem solving with the reoccurring issues based on downtime but production is not. KPI is recorded by production downtime trackers, but only coordinators analyzes the KPI. KPI information is presented but problem solving is ineffective. There is no consistent practices.
What training or reinforcement exists to maintain a "one voice" system among the management team?	Management also attends monthly communication meetings and engineers are encouraged to talk to maintenance about repeating issues. Furthermore, each line engineer (me) is to hold a daily meeting with process engineering, maintenance coordinator, quality engineers, and we are pushing to have production coordinators involved. I have also been invited to attend the MRB meetings for Line 3. Management from all departments. Process engineering goes over downtime, cycle time, and process changes within their whole department.

2. Operations Environment

A. In Terms of Resources:

Assessment Criteria	Explanations & Examples
How clear are people's roles?	Our engineering department does not have standardized work. Maintenance coordinators do have standardized work and a roles and responsibility file. Floor workers have clear roles but no standardized work. SOP for production is written by process engineering. Engineering (reliability and process) roles are dependent on what process need to be implemented or current situation. *(Draw out the org roles and responsibilities for your department on another page using the template on the following page as an example)*
Is the training for these roles clearly defined so that the role is maintained when the people that fill them change?	No, my role has changed from being a reliability engineer, to working on random projects, to switching to another line as a reliability engineer. There is no standardized work, and no clear roles.
How do these roles support a Problem Solving environment?	Since there is no standardized role, everyone has their own ideas for a solution to the problem which is inconsistent with standard problem solving methods. It creates difficult problem solving environment.

2. Operations Environment

B. For Daily Operations:

Assessment Criteria	Explanations & Examples
Are standards clearly in place for quality, time and cost?	Our standard deal with meeting number of frames to Ford while dealing quality defects and trying to get green level of audit. Implementation of certain PMs and process changes have to be meant within a time frame. Each department has a budget as well.
Are these standards linked to the customer's demand/needs?	Yes, production and maintenance runs depending on the demand of the product, for quality we are trying to get the green level audit.
Is there a clear separation of normal and abnormal work? Whose role is it to perform the abnormal work?	Most of engineering work is based on abnormal work and to fix them eight step problem solving.

2. Operations Environment

C. Continuous Improvement:

Assessment Criteria	Explanations & Examples
How is visual management used to identify problems for continuous improvement activities?	Engineers look at the downtime production reports as well as KPIs and see the most occurring and heavy hitters. We have an and on in place with verbal communication through radios for abnormal maintenance issues.
What key performance indicators are used for continuous improvement?	Production KPI, quality KPI, safety KPI information is analyzied and used by engineering for improvement.
Is there a consistent problem solving method used in all continuous improvement activities?	Yes, all engineers are trained under the Toyota Eight Step Problem Solving. Presentations are always based on this format throughout all departments, production, maintenance, and safety.

2. Operations Environment

D. In Terms of Process Flow:

Assessment Criteria	Explanations & Examples
How connected is the physical flow?	The physical flow of material is through the work orders that are generated by they are also digital as well as we use eMaint. The PMs are generated on there, and then printed, but not all of it is always returned in the physical form to close out.
What method is utilized to connect/manage the information flow?	A push system based on a scheduled PMs/work orders from the manufacturing equipment. The schedulers and planners are the ones in charge of putting on the information while the maintenance coordinators select which ones to take care of based on manpower. Physical paper is the best way to current do this for our system.

1. Culture

A. Creating a Positive Work Environment

Assessment Criteria	Explanations & Examples
Is there trust in management? How is it measured?	Team members tend to have trust in coordinators and support but when it comes to engineering or management, the leveled of trust is a lot lower. Trust would be measured in what the feedback of improvement or changes they are willing to give us as well as the general attitude when approached by management.
What opportunities exist for people throughout the organization to participate in improvement activities?	The reliability engineers are tasked with presenting cost savings ideas and OA improvement A3's within each of our dedicated lines. Engineers are also tasked with attending meetings with maintenance and production coordinators while giving and receiving feedback from both. Team leads participate in MBT meetings, but that is as far as they go.
What outlets exist for people development?	For the floor workers, operators have the chance to become team leads, weld techs, or an apprentice for maintenance. For management and engineers, training from the TPS system is paid for, as well as technical course based on weld tech / maintenance duties are given to salary employees.
How is team spirit gauged?	Team spirit would be gauged by how well of a run our dedicated lines runs during the hours we are present. Bad production shifts tends to have a negative impact on coordinators and engineers. For management and engineers, if more random abnormal task are given to us, usually the team spirit is lower.

1. Culture

B. People Side--At all levels within the organization (executive, management, operations) how are your competencies supportive of a lean culture? Provide details in terms of the following areas:

Assessment Criteria	Explanations & Examples
Performance Evaluation	The company is currently not a lean organization and still in a push system. Performance has been more steady compared to the past but still not very consistent.
Management Development	Management is currently sending only certain engineers and coordinators for lean training and there has been no talk between team members on the floor and management at all about moving towards a lean culture.
Compensation	As of right now, compensation has not been sacrificed for team members on the floor. There is still a lot of spending for travel and training that salary employees benefit more so then the floor workers. Floor workers are currently given temporarily layoff to compensate for overmanning. Money has been spent to improve the facilities for team members though.
Succession Planning	The move towards a lean environment has been addressed once during a monthly communication meeting just within the maintenance salary department.

1. Culture

C. Problem Solving practices at all levels (executive, management, operations)

Assessment Criteria	Explanations & Examples
What systematic problem solving methods are used?	Engineering and management all use the 8-step problem solving (A3) format. The problem arise when some employees use a different format for it or a different scope of work such as A3's that include multiple projects and trying to improve all areas of an assembly line.
Is it a safe environment for problem solving?	Steps 1-3 are very safe, but implementing countermeasures tend to get negative feedback as long time employees do not like change. Sometimes countermeasures do not work right away and need to be debugged or new methods of the countermeasure need to be applied. Most of step 4-6 can only be done during shutdown and not safe until then.
How are problems prioritized to work on first?	For A3 problem solving, the issue that causes the most cost or downtime are addressed first. For daily or weekly smaller issues, work orders are created and addressed during PM shutdowns on the weekend. The hot topic of the week is prioritized but forgotten quickly the next week.
What activities for engagement/recognition exist for problem solving?	During the meetings, the daily abnormalities and downtime issues from the last day are addressed and presented to the coordinator. The only time production & maintenance coordinators, engineering, and management is all involved is during the short MBT meetings a few minutes. Problem solving is only done by engineering for "root causes" or reducing cycle time. For general maintenance, the coordinators handle that.

APPENDIX C: RAPIDMINER PROCESS DESCRIPTIONS

Process Documents from Files Operator

Synopsis: Generates word vectors from a text collection stored in multiple files.

Input: Example Set

Output: (1) Example Set, (2) Word List

Parameters

text directories (optional)
In this list arbitrary directories can be specified. All files matching the given file ending will be loaded and assigned to the class value provided with the directory.
Type: *list*
file pattern (optional)
A pattern for the file to be read. Usual wildcards like ? and * are supported.
Type: *string* Default: *
extract text only (optional)
If checked, structural information like xml or html tags will be ignored and discarded.
Type: *boolean* Default: *true*
use file extension as type (optional)
If checked, the type of the files will be determined by their extensions. Unknown extensions will be treated as text files.
Type: *boolean* Default: *true*
content type (optional)
The content type of the input texts
Type: *selection* Range: *txt, pdf, xml, html* Default: *txt*
encoding (optional)
The encoding used for reading or writing files.
Type: *selection* Range: *SYSTEM, Big5, Big5-HKSCS, CESU-8, EUC-JP, EUC-KR, GB18030, GB2312, GBK, IBM-Thai, ...* Default: *SYSTEM*
create word vector (optional)
If checked, the tokens of a document will be used to generate a vector numerically representing the document.

Type: *boolean* Default: *true*
vector creation
Select the schema for creating the word vector.
Type: *selection* Range: *TF-IDF, Term Frequency, Term Occurrences, Binary Term Occurrences* Default: *TF-IDF*
add meta information (optional)
If checked, available meta information of the text like filename, date is added as attribute.
Type: *boolean* Default: *true*
keep text (optional)
If checked, the input text will be stored as a special String attribute with the role text.
Type: *boolean* Default: *false*
prune method (optional)
Specifies if to frequent or to infrequent words should be ignored for word list building and how the frequencies are specified.
Type: *selection* Range: *none, percentual, absolute, by ranking* Default: *none*
prune below percent (optional)
Ignore words that appear in less than this percentage of all documents.
Type: *real* Range: *0.0 - 100.0* Default: *3.0*
prune above percent (optional)
Ignore words that appear in more than this percentage of all documents.
Type: *real* Range: *0.0 - 100.0* Default: *30.0*
prune below absolute (optional)
Ignore words that appear in less than that many documents.
Type: *integer* Range: *0 - +∞*
prune above absolute (optional)
Ignore words that appear in more than that many documents.
Type: *integer* Range: *0 - +∞*
prune below rank (optional)
Words are ordered by frequency and words with a frequency less than the frequency of the rank given by this percentage will be pruned.

Type: *real* Range: *0.0 - 1.0* Default: *0.05*
prune above rank (optional)
Words are ordered by frequency and words with a frequency higher than the frequency of the rank given by this percentage will be pruned.
Type: *real* Range: *0.0 - 1.0* Default: *0.95*
datamanagement (optional)
Determines, how the data is represented internally.
Type: *selection* Range: *double_array, float_array, long_array, int_array, short_array, byte_array, boolean_array, double_sparse_array, float_sparse_array, long_sparse_array, ...* Default: *double_sparse_array*
parallelize vector creation
Determines whether the execution of Vector Creation should be parallelized.

Sub-Processes within “Process Document from Files” Operator

Transform Cases Text Processing

Synopsis

Transforms cases of characters in a document.

Description

This operator transforms all characters in a document to either lower case or upper case, respectively.

Input: document

Output: document

Parameters

transform to (optional)
Specifies whether tokens should be converted to lowercase or uppercase, respectively.
Type: *selection* Range: *lower case, upper case* Default: *lower case*

Tokenize Text Processing

Synopsis

Tokenizes a document.

Description

This operator splits the text of a document into a sequence of tokens. There are several options how to specify the splitting points. Either you may use all non-letter character, what is the default settings. This will result in tokens consisting of one single word, what's the most appropriate option before finally building the word vector

Or if you are going to build windows of tokens or something like that, you will probably split complete sentences, this is possible by setting the split mode to specify character and enter all splitting characters.

The third option lets you define regular expressions and is the most flexible for very special cases. Each non-letter character is used as separator. As a result, each word in the text is represented by a single token.

Input: document

Output: document

Parameters

mode (optional)
This selects the tokenization mode. Depending on the mode, split points are chosen differently.
Type: *selection* Range: *non letters, specify characters, regular expression, linguistic sentences, linguistic tokens* Default: *non letters*
characters (optional)
The incoming document will be split into tokens on each of this characters. For example enter a '.' for splitting into sentences.
Type: *string* Default: *.:*
expression (optional)
This regular expression defines the splitting point.
Type: *string*
language (optional)
The language for the used part of speech (POS) tagger.

Type: *selection* Range: *English, German, Generic Asian* Default: *English*
max token length (optional)
The maximal token length of the tokens
Type: *integer* Range: *1* - +∞ Default: *3*

Filter Stopwords (English) Text Processing

Synopsis

Removes English stopwords from a document.

Description

This operator filters English stopwords from a document by removing every token which equals a stopword from the built-in stopword list. Please note that, for this operator to work properly, every token should represent a single English word only. To obtain a document with each token representing a single word, you may tokenize a document by applying the Tokenize operator beforehand.

Input: document

Output: document

Filter Tokens (by Length) Text Processing

Synopsis

Filters tokens based on their length.

Description

This operator filters tokens based on their length (i.e. the number of characters they contain).

Input: document

Output: document

Parameters

min chars (optional)
The minimal number of characters that a token must contain to be considered.
Type: *integer* Range: *0* - +∞ Default: *4*
max chars (optional)
The maximal number of characters that a token must contain to be considered.
Type: *integer* Range: *0* - +∞ Default: *25*

Generate n-Grams (Terms) Text Processing

Synopsis

Creates term n-Grams of tokens in a document.

Description

This operator creates term n-Grams of tokens in a document. A term n-Gram is defined as a series of consecutive tokens of length n. The term n-Grams generated by this operator consist of all series of consecutive tokens of length n.

Input: document

Output: document

Parameters

max length (optional)
The maximal length of the n-Grams.
Type: *integer* Range: *1* - +∞ Default: *2*

APPENDIX D: TERM & DOCUMENT FREQUENCIES

Word	Total Occurrences	Document Occurrences
management	3637	233
problem	3613	233
solving	3157	233
problem_solving	3073	233
people	1932	233
improvement	1918	233
training	1898	233
environment	1811	232
operations	1811	233
criteria	1722	223
culture	1686	233
explanations	1653	214
roles	1576	232
process	1493	233
examples	1328	220
assessment	1326	224
activities	1307	232
assessment_criteria	1276	221
explanations_examples	1249	214
performance	1236	232
continuous	1213	232
continuous_improvement	1166	232
quality	1142	232
problems	1111	231
organization	1064	230
development	1052	233
system	935	231
standards	922	230
abnormal	909	232
employees	895	165
level	860	190
clear	854	232
operations_environment	854	228
criteria_explanations	838	213
exist	831	231
improvement_activities	814	230
levels	784	232
leadership	776	232
method	761	228
customer	751	231
behaviors	748	230
terms	728	227

Word	Total Occurrences	Document Occurrences
consistent	717	229
support	715	229
daily	688	233
employee	684	161
trust	682	231
production	673	152
clearly	665	228
place	658	232
areas	654	224
defined	654	230
department	621	222
culture_assessment	608	203
company	580	172
based	569	178
standard	562	172
managers	561	164
opportunities	557	228
information	555	230
executive	542	226
members	537	142
safety	492	167
manager	485	165
currently	477	153
teams	472	136
normal	470	231
executive_management	459	223
visual	457	229
identify	455	229
exist_people	454	228
management_operations	445	222
compensation	437	229
change	436	230
using	433	218
business	431	129
planning	428	230
recognition	419	229
succession	417	229
spirit	414	229
participate	412	229
voice	406	231
explanations_criteria	404	200
provide	403	226
example	402	211
criteria_clear	401	201
engagement	398	228

Word	Total Occurrences	Document Occurrences
leaders	393	120
issues	386	142
measured	376	230
systematic	376	229
evaluation	374	229
goals	374	148
meetings	369	145
physical	368	231
trust_management	367	228
perform	366	226
normal_abnormal	359	228
visual_management	356	229
linked	355	228
methods	355	229
succession_planning	347	227
connected	344	226
clearly_defined	342	226
resources	342	231
systematic_problem	340	229
working	337	144
demand	334	227
solving_method	330	225
practices	325	228
current	323	137
positive	321	230
plant	320	95
separation	317	228
exists	314	223
performance_evaluation	312	227
program	312	130
management_development	298	228
manage	296	227
competencies	291	225
customer_demand	289	225
indicators	288	224
prioritized	288	227
creating	286	230
product	285	112
gauged	282	229
clear_separation	280	226
voice_system	280	228
focus	279	124
maintain	279	228
support_problem	279	225
utilized	279	226

Word	Total Occurrences	Document Occurrences
separation_normal	278	227
environment_problem	277	225
linked_customer	276	226
boards	273	122
people_development	272	227
supportive	270	227
leader	269	102
quality_standards	269	217
solving_environment	268	225
group	264	111
nurturing	264	223
roles_clearly	264	223
standards_linked	264	225
tools	264	121
behaviors_consistent	263	221
levels_organization	263	224
spirit_gauged	262	229
solving_methods	259	226
behaviors_culture	258	223
maintained	258	224
reinforcement	256	224
connect	255	224
consistent_management	254	222
consistent_problem	254	224
participate_improvement	254	228
identify_problems	252	225
solving_problem	252	208
perform_abnormal	251	223
place_quality	251	227
floor	250	113
problems_prioritized	250	222
roles_support	250	225
people_roles	249	221
explain	248	223
results	248	110
develop	247	120
training_roles	247	223
daily_operations	246	231
performance_indicators	246	224
processes	246	117
solving_problems	246	206
outlets	243	226
manage_information	242	224
meeting	242	115
supportive_culture	242	223

Word	Total Occurrences	Document Occurrences
maintain_voice	241	226
nurturing_behaviors	241	222
opportunities_exist	241	227
engagement_recognition	240	226
details	239	222
review	238	120
standards_clearly	238	223
training_reinforcement	237	224
clearly_place	236	223
management_measured	236	222
activities_engagement	234	227
connect_manage	234	224
management_nurturing	233	222
people_change	233	223
people_organization	233	225
problems_continuous	233	223
method_continuous	232	222
positive_environment	232	229
events	231	99
creating_positive	230	229
management_identify	230	223
solving_practices	230	227
system_management	230	224
connected_physical	229	224

APPENDIX E: BINARY MATRIX

Survey #	Y1	X1	X2	X3	X4	X5	X6
1	1	1	0	1	1	1	1
2	1	0	1	0	0	0	0
3	1	1	0	1	0	0	0
4	1	0	0	0	1	0	0
5	1	0	1	0	0	0	0
6	1	1	0	0	0	0	0
7	1	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	1	0	1	0	0	1	0
10	1	0	0	1	0	1	0
11	1	1	0	1	0	0	0
12	1	0	1	1	1	1	0
13	1	1	0	1	1	0	0
14	0	0	0	0	0	0	0
15	1	0	1	0	1	1	0
16	1	0	0	0	0	0	0
17	0	0	0	0	0	0	0
18	1	1	0	1	0	0	0
19	0	0	0	1	1	0	0
20	1	0	0	0	0	1	0
21	1	1	0	0	0	0	1
22	1	0	0	0	0	0	0
23	1	0	1	1	0	0	0
24	1	1	0	1	0	0	0
25	0	0	0	0	0	0	0
26	1	1	0	0	0	1	0
27	1	0	1	0	0	0	0
28	1	1	0	0	0	1	0
29	1	0	0	0	0	0	0
30	1	0	1	1	1	0	1
31	1	0	0	1	0	0	0
32	1	1	0	0	0	0	0
33	1	0	1	0	0	0	0
34	1	0	0	1	0	0	0

Survey #	Y1	X1	X2	X3	X4	X5	X6
35	1	0	0	0	0	0	0
36	1	0	0	1	0	0	0
37	1	0	0	0	0	0	0
38	1	0	0	0	0	1	0
39	1	0	1	1	0	0	0
40	1	0	0	0	0	0	0
41	0	0	0	0	0	0	1
42	1	0	0	1	0	0	0
43	1	0	0	0	0	0	0
44	1	1	0	0	0	0	0
45	0	0	0	0	0	0	0
46	1	0	1	0	0	1	0
47	1	1	0	0	0	0	0
48	0	0	0	0	0	0	0
49	1	0	0	1	0	0	0
50	1	0	0	0	0	0	0
51	1	0	1	1	0	0	0
52	0	0	0	0	0	0	0
53	1	1	0	0	0	0	0
54	1	1	0	1	0	0	0
55	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0
57	1	1	0	1	0	1	0
58	0	0	0	0	0	0	0
59	1	0	1	1	0	0	0
60	0	0	0	0	0	0	0
61	1	0	1	1	1	0	0
62	0	0	0	0	0	0	0
63	1	1	0	0	0	0	0
64	1	1	0	1	0	0	0
65	1	0	1	0	0	1	0
66	1	0	0	0	0	0	0
67	1	1	0	0	0	1	0
68	1	0	1	1	0	1	0
69	1	0	1	1	0	0	0
70	0	0	0	0	0	0	0
71	1	0	1	0	1	1	0
72	1	0	0	1	0	0	0

Survey #	Y1	X1	X2	X3	X4	X5	X6
73	0	1	0	0	0	1	1
74	1	0	0	0	0	0	1
75	1	0	0	1	1	0	1
76	1	0	0	1	0	0	0
77	1	0	1	1	1	0	0
78	1	1	0	0	0	1	0
79	1	0	1	0	1	1	0
80	0	0	0	0	0	0	0
81	0	0	0	0	1	0	0
82	1	1	0	0	0	0	0
83	1	0	1	0	0	0	0
84	1	0	0	0	0	0	0
85	0	0	1	0	0	0	0
86	0	0	1	0	0	0	0
87	1	1	0	0	1	0	0
88	1	1	0	1	1	0	1
89	0	0	1	1	0	0	0
90	1	0	1	1	1	1	0
91	1	0	1	1	0	0	1
92	1	0	1	0	0	0	0
93	1	0	0	0	0	0	0
94	0	0	0	0	0	0	0
95	1	0	0	0	0	0	0
96	1	0	1	0	0	0	0
97	1	0	1	0	0	1	0
98	1	1	0	0	0	0	0
99	1	0	0	1	0	0	0
100	0	0	0	0	1	1	0
101	1	0	1	1	0	0	0
102	1	0	1	0	0	0	0
103	1	0	1	0	0	1	0
104	1	0	0	0	0	0	0
105	1	0	0	1	0	0	0
106	1	0	1	0	0	0	0
107	1	0	1	0	0	0	0
108	1	1	0	1	0	0	0
109	1	0	1	0	0	0	0
110	1	1	0	0	1	0	0

Survey #	Y1	X1	X2	X3	X4	X5	X6
111	1	1	0	0	0	0	0
112	1	1	0	1	0	0	1
113	1	0	1	0	0	0	1
114	1	1	0	1	0	0	0
115	0	0	1	0	0	0	0
116	0	1	0	0	0	1	0
117	1	0	0	0	0	0	0
118	0	0	1	0	0	0	0
119	1	0	0	0	0	0	0
120	1	0	1	1	0	0	1
121	1	0	1	0	0	0	1
122	1	0	1	0	0	0	0
123	1	0	1	1	1	1	0
124	1	0	0	1	0	0	0
125	1	0	1	0	0	0	0
126	1	0	1	1	1	1	0
127	0	0	0	1	0	0	0
128	0	0	1	0	0	0	0
129	1	0	1	1	0	1	0
130	1	0	0	1	0	0	0
131	1	0	1	0	0	0	0
132	1	0	1	0	1	1	1
133	1	0	0	0	0	0	0
134	1	0	1	0	1	1	0
135	1	0	1	0	0	0	0
136	1	0	1	0	0	0	0
137	1	0	1	1	0	0	0
138	1	0	1	1	0	0	0
139	1	0	0	0	0	0	0
140	0	0	1	0	0	0	0
141	1	0	1	1	0	0	0
142	1	1	0	1	1	0	0
143	1	0	0	1	0	1	0
144	1	0	1	1	1	1	1
145	0	0	1	1	0	0	0
146	1	0	1	1	0	1	0
147	0	0	1	1	1	0	1
148	1	0	1	0	0	0	0

Survey #	Y1	X1	X2	X3	X4	X5	X6
149	1	0	1	1	0	1	0
150	1	0	1	0	1	1	0
151	0	0	1	0	0	0	0
152	1	1	0	0	0	0	0
153	0	0	0	1	0	0	0
154	1	0	1	1	0	0	1
155	1	1	0	1	0	0	0
156	1	0	0	0	0	0	0
157	1	0	0	0	0	0	0
158	1	1	0	1	0	0	0
159	1	0	1	0	0	0	0
160	1	1	0	1	0	0	0
161	0	0	0	0	0	0	0
162	1	0	1	0	0	0	0
163	1	0	1	1	0	0	0
164	0	0	0	1	0	0	0
165	1	0	1	0	0	0	0
166	1	0	0	1	0	0	0
167	1	1	0	0	0	1	0
168	1	0	1	0	0	0	0
169	1	0	1	1	0	0	0
170	1	0	0	1	0	0	0
171	1	0	1	0	0	0	0
172	0	0	0	0	1	1	0
173	0	0	1	0	0	0	1
174	0	0	1	1	0	1	0
175	1	0	1	0	0	0	0
176	1	0	1	0	0	0	0
177	1	1	0	0	0	1	0
178	1	0	1	1	1	0	0
179	1	0	1	1	0	0	0
180	1	0	1	1	1	1	0
181	1	0	1	1	0	0	0
182	1	1	0	1	1	1	1
183	0	0	1	1	1	1	0
184	1	1	0	0	0	0	0
185	1	0	1	1	0	1	0
186	1	0	1	0	0	0	0

Survey #	Y1	X1	X2	X3	X4	X5	X6
187	1	0	1	0	0	0	0
188	1	0	0	0	0	0	0
189	1	0	0	0	0	1	0
190	1	0	0	0	0	0	1
191	1	0	1	1	0	0	0
192	1	0	1	0	0	0	0
193	1	0	1	1	0	1	0
194	1	0	1	1	0	0	0
195	1	1	0	0	0	1	0
196	1	0	0	0	0	0	0
197	1	0	1	1	0	0	0
198	1	0	1	1	1	1	0
199	1	1	0	0	0	1	0
200	0	0	1	1	0	0	0
201	0	0	0	0	0	0	0
202	1	0	1	0	1	0	0
203	1	0	0	0	0	0	1
204	1	0	1	0	0	0	0
205	1	0	1	0	0	0	0
206	0	0	0	0	1	1	0
207	0	0	0	0	0	0	0
208	1	0	1	0	0	0	0
209	0	0	1	1	1	0	0
210	1	0	1	1	0	0	0
211	1	0	1	0	1	1	0
212	1	0	1	0	0	0	0
213	1	0	1	1	0	0	0

APPENDIX F: SAS PROGRAM CODE

Variables Key:

X1	One Problem solving Method Defined
X2	Multiple Problem solving Methods Defined
X3	Standard Work documented
X4	Training Method Defined
X5	Roles Defined
X6	Normal & Abnormal Work Separate
Y1	Problem Solving Outlets

SAS Frequency Statistics Code

```
FILENAME REFFILE 'C:/Users/dmpars2/Desktop/Final PhD Dataset
11_24_17.xlsx';

PROC IMPORT DATAFILE=REFFILE
      DBMS=XLSX
      OUT=WORK.Results
      replace;
      GETNAMES=YES;
      SHEET="PS Methods Split";

PROC freq DATA=WORK.Results;
table y1 x1 x2 x3 x4 x5 x6;
  run;
  quit;
```

SAS Correlation Code

```
FILENAME REFFILE 'C:/Users/dmpars2/Desktop/Final PhD Dataset
11_24_17.xlsx';

PROC IMPORT DATAFILE=REFFILE
      DBMS=XLSX
      OUT=WORK.Results
      replace;
      GETNAMES=YES;
      SHEET="PS Methods Split";

proc corr;
var x1 x2 x3 x4 x5 x6;

run;


PROC corr;
var x1 x3;

run;


proc corr;
var x1 x2;

run;


proc corr;
var x2 x3;

run;
```

SAS Binary Logistic Regression Code

```
FILENAME REFFILE 'C:/Users/dmpars2/Desktop/Final PhD Dataset
11_24_17.xlsx';

PROC IMPORT DATAFILE=REFFILE
      DBMS=XLSX
      OUT=WORK.Results
      replace;
      GETNAMES=YES;
      SHEET="PS Methods Split";

PROC logistic DATA=WORK.Results descending;
model y1 = x1-x6;
  run;
quit;


PROC logistic DATA=WORK.Results descending;
model y1 = x1-x3;
  run;
quit;


PROC logistic DATA=WORK.Results descending;
model y1 = x1 x3;
  run;
quit;


PROC logistic DATA=WORK.Results descending;
model y1 = x2 x3;
  run;
quit;
```

APPENDIX G: SAS RESULTS

The FREQ Procedure

Y1	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	44	20.66	44	20.66
1	169	79.34	213	100

X1	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	171	80.28	171	80.28
1	42	19.72	213	100

X2	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	114	53.52	114	53.52
1	99	46.48	213	100

X3	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	130	61.03	130	61.03
1	83	38.97	213	100

X4	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	177	83.1	177	83.1
1	36	16.9	213	100

X5	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	165	77.46	165	77.46
1	48	22.54	213	100

X6	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	192	90.14	192	90.14
1	21	9.86	213	100

Correlation for X1 through X6

The CORR Procedure

6 Variables: X1 X2 X3 X4 X5 X6

Simple Statistics							
Variable	**N**	**Mean**	**Std Dev**	**Sum**	**Minimum**	**Maximum**	**Label**
X1	213	0.19718	0.39881	42	0	1	X1
X2	213	0.46479	0.49993	99	0	1	X2
X3	213	0.38967	0.48882	83	0	1	X3
X4	213	0.16901	0.37565	36	0	1	X4
X5	213	0.22535	0.4188	48	0	1	X5
X6	213	0.09859	0.29882	21	0	1	X6

Pearson Correlation Coefficients, N = 213 Prob > |r| under H0: Rho=0	X1	X2	X3	X4	X5	X6	
X1	1	-0.46184	0.03953	-0.0031	0.09984	0.07359	r
X1		<.0001	0.5661	0.9641	0.1464	0.285	p-value
X2	-0.46184	1	0.12397	0.13231	0.10567	0.00756	r
X2	<.0001		0.071	0.0538	0.1242	0.9127	p-value
X3	0.03953	0.12397	1	0.17909	0.02986	0.09097	r
X3	0.5661	0.071		0.0088	0.6648	0.186	p-value
X4	-0.0031	0.13231	0.17909	1	0.35642	0.18703	r
X4	0.9641	0.0538	0.0088		<.0001	0.0062	p-value
X5	0.09984	0.10567	0.02986	0.35642	1	0.01009	r
X5	0.1464	0.1242	0.6648	<.0001		0.8836	p-value
X6	0.07359	0.00756	0.09097	0.18703	0.01009	1	r
X6	0.285	0.9127	0.186	0.0062	0.8836		p-value

Regression for X1 through X6

The LOGISTIC Procedure

Model Information	
Data Set	WORK.RESULTS
Response Variable	Y1
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	213
Number of Observations Used	213

Response Profile		
Ordered Value	Y1	Total Frequency
1	1	169
2	0	44

Probability modeled is Y1='1'.

Model Convergence Status
Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics		
Criterion	Intercept Only	Intercept and Covariates
AIC	218.996	205.248
SC	222.357	228.777
-2 Log L	216.996	191.248

Testing Global Null Hypothesis: BETA=0			
Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	25.7477	6	0.0002
Score	24.4712	6	0.0004
Wald	20.4533	6	0.0023

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	0.3612	0.2723	1.7594	0.1847
X1	1	2.3988	0.7744	9.5941	0.002
X2	1	1.1472	0.3875	8.7658	0.0031
X3	1	0.6956	0.4076	2.9121	0.0879
X4	1	-0.7085	0.5514	1.6514	0.1988
X5	1	0.4212	0.5442	0.599	0.439
X6	1	-0.0389	0.6361	0.0037	0.9512

Odds Ratio Estimates			
Effect	**Point Estimate**	**95% Wald Confidence Limits**	
X1	11.01	2.413	50.231
X2	3.149	1.474	6.73
X3	2.005	0.902	4.457
X4	0.492	0.167	1.451
X5	1.524	0.524	4.427
X6	0.962	0.277	3.346

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	68.6	**Somers' D**	0.471
Percent Discordant	21.5	**Gamma**	0.523
Percent Tied	9.9	**Tau-a**	0.155
Pairs	7436	**c**	0.736

Regression for X1 through X3

The LOGISTIC Procedure

Model Information	
Data Set	WORK.RESULTS
Response Variable	Y1
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	213
Number of Observations Used	213

Response Profile		
Ordered Value	Y1	Total Frequency
1	1	169
2	0	44

Probability modeled is Y1='1'.

Model Convergence Status
Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics		
Criterion	Intercept Only	Intercept and Covariates
AIC	218.996	201.005
SC	222.357	214.451
-2 Log L	216.996	193.005

Testing Global Null Hypothesis: BETA=0			
Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	23.9906	3	<.0001
Score	22.9258	3	<.0001
Wald	19.3349	3	0.0002

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	0.3488	0.2635	1.752	0.1856
X1	1	2.4213	0.7667	9.9744	0.0016
X2	1	1.1238	0.3763	8.9181	0.0028
X3	1	0.6235	0.399	2.4418	0.1181

Odds Ratio Estimates			
Effect	**Point Estimate**	**95% Wald Confidence Limits**	
X1	11.26	2.506	50.596
X2	3.077	1.471	6.433
X3	1.865	0.853	4.078

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	62.6	**Somers' D**	0.442
Percent Discordant	18.4	**Gamma**	0.545
Percent Tied	18.9	**Tau-a**	0.145
Pairs	7436	**c**	0.721

Regression for X1 and X3

The LOGISTIC Procedure

Model Information	
Data Set	WORK.RESULTS
Response Variable	Y1
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	213
Number of Observations Used	213

Response Profile		
Ordered Value	Y1	Total Frequency
1	1	169
2	0	44

Probability modeled is Y1='1'.

Model Convergence Status
Convergence criterion (GCONV=1E-8) satisfied.

Deviance and Pearson Goodness-of-Fit Statistics				
Criterion	Value	DF	Value/DF	Pr > ChiSq
Deviance	1.278	1	1.278	0.2583
Pearson	0.7756	1	0.7756	0.3785

Model Fit Statistics		
Criterion	Intercept Only	Intercept and Covariates
AIC	218.996	208.271
SC	222.357	218.355
-2 Log L	216.996	202.271

Testing Global Null Hypothesis: BETA=0			
Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	14.7248	2	0.0006
Score	12.1537	2	0.0023
Wald	10.2599	2	0.0059

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	0.8599	0.2108	16.638	<.0001
X1	1	1.8633	0.7486	6.1956	0.0128
X3	1	0.7894	0.3874	4.152	0.0416

Odds Ratio Estimates			
Effect	**Point Estimate**	**95% Wald Confidence Limits**	
X1	6.445	1.486	27.951
X3	2.202	1.031	4.705

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	45.6	**Somers' D**	0.31
Percent Discordant	14.6	**Gamma**	0.516
Percent Tied	39.8	**Tau-a**	0.102
Pairs	7436	**c**	0.655

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