An Evaluation of the Risks of Maturity Assessments in Lean Production Systems

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Abstract

Over the past twenty years there has been significant attention given to applying metrics and evaluation criteria to the “leanness” of an organization. A desire to assess the effectiveness and efficiency in which an organization implements lean principles has driven the development of tools to analyze the maturity of an organizations lean transformation. In addition, educational programs aimed at measuring a company’s progress on a lean journey have been created to train managers how to assess their processes. This paper aims to review these assessments and the effects they have on managers who have a tendency to place focus on achieving performance metrics in order to obtain a higher performance appraisal score rather than addressing the root cause of waste in their processes. A result of misguided focus is that no real improvement takes place. Instead a series of quick fixes designed to address symptoms of the problem are implemented, and the organization ultimately reverts back to the comfort zone of a batch-and-queue system. A comparison of the assessment tools to the principles of progressive management, along with a discussion of existing lean management tools is included in the results.

Problem Definition

Is there a benefit to developing and implementing maturity assessments in a lean manufacturing environment? What are the driving forces behind creating maturity assessments? How do maturity assessments relate to the principles of lean production, and are there tools that already exist which will provide greater value to the business?

Research Objective

One of the most difficult elements of a lean transformation in a business is the ability of any employee (shop floor worker to senior managers) to buy into a system that goes against everything they have become accustom to throughout their career. Lean implementations typically occur in organizations that have been driven by batch-and-queue processes, with managers who implement a command and control style of leadership, often micromanaging every aspect of the operation. The research aims to determine if the development and use of lean assessment tools is a benefit to the organization that will drive the implementation of lean principles and ensure its success; or if the lean assessment tool is the result of a culture unable to move past a batch-and-queue history and embrace a progressive management process. Focus will be placed on the data collection method, the category of metrics collected, and the use of the information for continuous improvement.

Research Method

Descriptive Qualitative Meta-Research

According to Dr. Steven Goodman, MD, MHS, & PhD, the co-director of METRICS (MeTa Research Innovation Center at Stanford), meta research can be defined simply as research done on past research (Goodman, 2014). It is important to review the work of others, and evaluate the criteria used in the research to develop the results and conclusion of the study. In some instances it is difficult to determine if the proper course has been taken by reviewing only once case. Therefore, it is critical to review multiple cases to accurately understand the results of the research.

An extensive literature review was completed focusing on two specific aspects of lean management. The first subject will be a review of the history of lean management and the original intent of the men who contributed the most to its development. The second, a review of the modern day interpretation of the system, expectations of its application, and a review of the tools that have been developed to assess the implementation of lean in a business. Given the wide range of the applications of lean principles in the last decade, the scope of the research will be focused on lean production. However, in cases in which an encompassing theme is discovered in another industry, such as government or health care, it may be used to reinforce the findings of the research.

Literature Review

History of Lean Management

Lean is a system of management based on two key principles: continuous improvement, and respect for people (Taylor, 2010; Ohno, 1988; Monden, 2012; Woollard & Emiliani, 2009; Gajewski, 2014). These principles were understood and practiced by; Frederick Winslow Taylor in the steel yards of Pennsylvania in the early 20th century (Taylor, 2010), Henry Ford at Ford Motor Company (Ford, 1988), Frank G. Woollard at Morris Motors in the United Kingdom during the 1920's (Woollard & Emiliani, 2009), and Taiichi Ohno at Toyota Motor Company (Toyota) beginning in the 1950's (Ohno, 1988; Ohno, 2013; Dennis, 2007). Each man understood, and further developed the tools and principles that would become the lean management system as it is understood today.

Taylor (2010) understood that without a mutually beneficial relationship between the employer and employees, long term success for the business could not be sustained. He was one of the first practitioners who understood the root causes of worker inefficiency; fear of job loss, defective management systems, and a lack of standard work (Taylor, 2010). In order to address the inefficiencies he observed, Taylor set up a management system in which any worker displaced by efficiency improvements made, would be reassigned to another job within the company. In addition, standard work tasks were evaluated and designed so that a worker could thrive over a long career, rather than being run down and over-worked (Taylor, 2010). Workers were evaluated and selected to be trained based on individual traits that would ensure their success, thereby winning over other employees who may have resisted the significant culture change that was being presented (Taylor, 2010). Although Taylor believed in respect for the worker, he did not believe that a man performing manual labor had the education to provide valuable input into the design of the standard work. As a result, all of the time studies were performed and evaluated by men with college educations, and the best way to perform the job was determined based on this analysis (Taylor, 2010).

Frank G. Woollard established eighteen basic principles required for the implementation of flow production. Among these principles, Woollard identified the 18^{th}, "The system of production must benefit everyone – consumers, workers, and owners", as the one that must be fulfilled in order for a flow system to reach its full potential (Woollard & Emiliani, 2009). Over a period of two years beginning in 1923, Woollard was able to transform the Morris Motor Company from a batch-and-queue system to flow production. Faced with opposition from several members of management, Woollard had the confidence and support of the owner, William Morris, which allowed him to achieve success (Emiliani, 2010).

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18 Principles for Flow Production

1. a. Mass production demands mass consumption
   b. Flow production requires continuity of demand
2. The production of the system must be specified
3. The products of the system must be standardized
4. The products of the system must be simplified in general and in detail
5. All material supplies must conform to specification
6. All supplies must be delivered to a strict timetable
7. The machines must be continually fed with sound material
8. Processing must be progressive and continuous
9. A time cycle must be set and maintained
10. Operations must be based on motion study and time study
11. Accuracy of work must be strictly maintained
12. Long-term planning based on precise knowledge, is essential
13. Maintenance must be by anticipation – never by default
14. Every mechanical aid must be adopted for man and machine
15. Every activity must be studied for the economic application of power
16. Information on costs must be promptly available
17. Machines should be designed to suit the task they perform
18. The system of production must benefit everyone – consumers, workers and owners

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Figure 1 Principles for Flow Production (Woollard & Emiliani, 2009)

The research of Emiliani (2010) indicates that the principles developed by Woollard at Morris Motors may have served as inspiration for Kiichiro Toyoda, the founder of Toyota Motor Company. During a December 1929 visit to the U.K. By 1938, Kiichiro Toyoda had embraced the Just-In-Time philosophy of flow production, and planned to eliminate wastes within the work processes (Liker, 2004).

Eight Types of Waste (Muda)

1. Overproduction: Defies the fundamentals of Just-In-Time production as inventory is produced earlier than needed. This is the worst waste as it generates every other waste as a secondary waste.
2. Waiting: Time workers sit idle while machines run or are unable to proceed to the next step
3. Transportation: Carrying WIP long distances between processes or in and out of storage
4. Over Processing: Taking extra steps to process a part. Includes steps that provide a higher than necessary level of quality
5. Excess Inventory: Raw material, WIP, or finished goods that hide production problems such as imbalance, defects, downtime, and long change overs.
6. Motion: Excess motion by employees caused by poor layout, or standard work
7. Defects: Production of defective parts or rework
8. Non-value Added Behavior: Due to disregard of the respect for people principle. This refers to any actions, or behaviors that result in lost time, ideas, or skills by failing to engage employees.

Figure 2 Eight types of waste (Ohno, 1988; Liker, 2004; Gajewski, 2014)

Like Woollard at Morris Motors, Kiichiro Toyoda had the full confidence of the chairman, Eiji Toyoda, which was a significant factor in the development of the Toyota Production System (Ohno, 2013). The principles of the Toyota Production System, developed by Taiichi Ohno, were based on two main pillars, continuous improvement and respect for people (Taylor, 2010; Ohno, 1988; Monden, 2012; Woollard & Emiliani, 2009). The same ideals can be found in Taylor's

(2010) *Scientific Management* and Woollard's (2009) *Principles of Mass and Flow Production*. As with many innovations in industry, the development of the Toyota Production System was the result of the need for improved productivity and cost reduction. Japanese manufactures faced difficult markets after World War II, which demanded low volume and high product variation (Dennis, 2007). As a result, Toyota could not directly implement the American industrial practices and industrial engineering techniques that many in Japan were attempting to emulate (Ohno, 1988). It would have been impossible for them to acquire the capital investment for the machines, and levels of inventory to match the mass production seen in the United States.

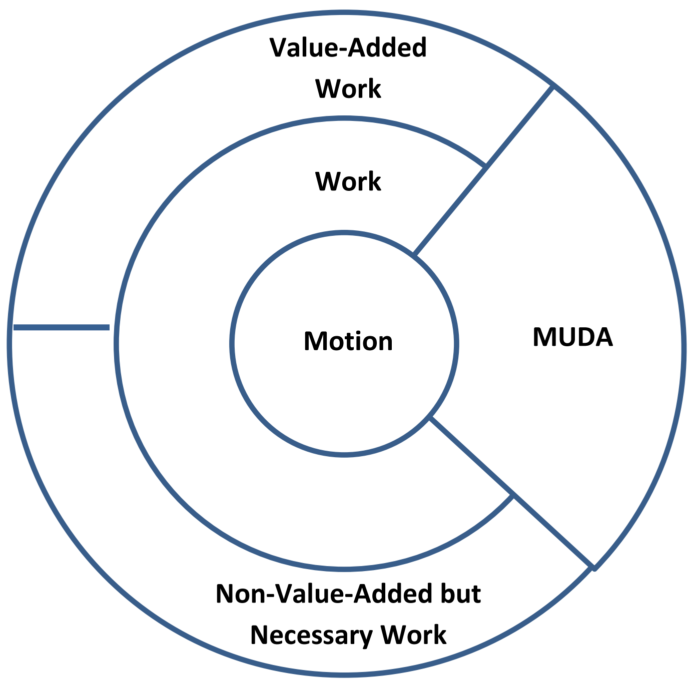

Figure 3 The breakdown of Muda (Waste) in a process (Dennis, 2007)

A reoccurring theme in Ohno's books is that the systems in place at Toyota are always being perfected, with continuous improvement being made daily (Ohno, 1988). Unlike Taylor, Ohno believed in the power of the knowledge of his workforce. The standard work procedures in the Toyota Production System are not dictated from management to the workforce, but rather are set up and improved daily by the supervisors and workers themselves (Ohno, 1988) (Ohno, 2013). Since, the Toyota Production System is forever in pursuit of production at a lower cost, there is no end to the system (Ohno, 2013). One of the main tools utilized by Ohno in developing the Toyota Production System was the use of the "Go See", or genba, which means "to the place of work" (Liker, 2004). Many of the improvements made by Ohno came about in a similar manner as the work done by Henry Ford (1988), who described the process as "the Edison Method" of trial and error. In both cases, the development of the process had the full support of company leadership which allowed it to grow even through minor setbacks.

The innovations Ohno achieved at Toyota went largely unnoticed by the rest of the world in the years following World War II, until the oil crisis of the 1970's. The comparatively low impact of the crisis on Toyota due to not being over burdened by batch-and-queue processes, led others to study the Toyota Production System, and implement many of the tools they observed (Womack, Jones, & Roos, 1990). For much of the 1980's, the Toyota Production System was referred to as "Just-In-Time" production. Then, in the 1990's, it was described as "lean manufacturing" (Womack, Jones, & Roos, 1990; Hines, Holweg, & Rich, 2004), but continued to focus primarily on the tools used by Toyota. The key element of the system that was missing from the majority of attempts to repeat Toyota's success was the understanding that the Toyota Production System is not a set of tools to be applied, but rather a unique way of learning to solve problems. This gap was largely attributed to the cherry picking of "lean tools" and ignoring the mindset and culture required to sustain a lean transformation (Hines, Holweg, & Rich, 2004). In the mid to late 2000's, lean manufacturing began to be applied to other industries such as health care and government, becoming known as "Lean Management" (Emiliani M. L., 2013). Unlike a batch-and-queue system, a lean management system will always have the values of the customer as the main priority due to the shift of focus from a sellers' market, to a buyers' market.

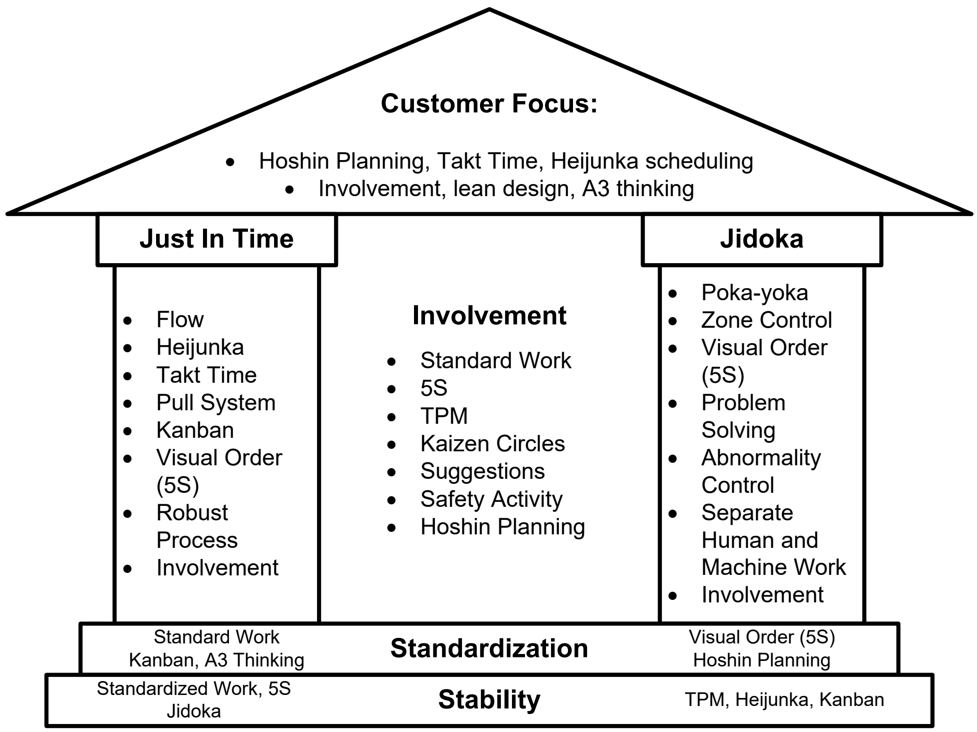

Figure 4 Toyota Production System Activities (Dennis, 2007)

The building blocks of the Toyota Production System are shown in Figure 4, and although cost reduction is a primary goal of the lean system, it does not show up as a tool or focus. When asked what Toyota is working on now, Taiichi Ohno replied "All we are doing is looking at the timeline" (Ohno, 1988). The timeline Mr. Ohno is referring to is the lead time between a customer placing an order and receipt of payment for that order. Although the company has been operating under its production system for over 60 years, the employees at Toyota are continuously finding ways to streamline processes, eliminate work in process inventory, and remove all wastes from the system (Ohno, 1988). The improvements are focused ultimately on the needs of the customers, and that simple clear goal provides focus to everything done at Toyota.

Shingijutsu-Kaizen

The heart of the Toyota Production System is the elimination of all non-value added waste in the system (Ohno, 1988; Liker, 2004; Emiliani, Yoshino, & Go, 2015) and the way to accomplish this is through Kaizen, or continuous improvement, at the genba, or place of work (Emiliani, Yoshino, & Go, 2015; Wood, Herscher, & Emiliani, 2015). The sensei at Shingijutsu USA began teaching the art of Kaizen in 1987 at the behest of Taiichi Ohno, and as the original pupils of Mr. Ohno, had first-hand knowledge of the methods and philosophy of TPS. Shingijutsu USA is regarded as the world leaders in the ways of genba kaizen, teaches that in order to master the basics, leaders must be spiritually committed to the long-term continuous improvement journey. In order to be successful, they must look to nature and visualize the mountain (the entire factory), the forest (the production line), and the trees (the process) simultaneously (Emiliani, Yoshino, & Go, 2015; Wood, Herscher, & Emiliani, 2015). By neglecting long term commitment, or ignoring any of the three levels of the enterprise, leaders may achieve limited short term success, but will ultimately fail to achieve sustainable success.

The Four Principles of Toyota Production System DNA

The Toyota Production System is based on four principles, known as its DNA (Spears & Bowen, 1999). These rules are meant to guide the design, operation, and improvement of the system. In a follow up paper, Spears (2004) reviews the training of a new manager hired who was previously a talented manager at a competitor. In it, the total immersion training of the manager is detailed through experiences at a U.S. engine plant, and then the Kamingo plant, where Taiichi Ohno developed many of the techniques seen in the Toyota Production System.

The majority of companies attempting to recreate Toyota's success fail to approach leadership training in the Toyota Production System the right way (Spears, 2004). The focus of training is placed on the plant walk-throughs and preliminary training sessions, but managers never experience the process through hands on immersion training at the genba. In addition, the use of "simple real-time experiments to continually improve operations" is a concept foreign (Spears, 2004) to managers familiar with a batch-and-queue environment in which every action is reviewed, critiqued, assigned a cost, and then approved or rejected by management. The use of total immersion training with quick simple experiments, under the guidance of a sensei (Ballé & Jones, 2014) allows the trainee to quickly generate feedback, and provide improvements without significant consequences (Spears, 2004).

The Four Rules of Toyota Production System

1. Activity Rule: All work shall be highly specified as to content, sequence, timing and outcome
2. Connection Rule: Every customer-supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive response.
3. Pathway Rule: The pathway for every product and service must be simple and direct.
4. Learning Rule: Any improvement must be made in accordance with the scientific method, under the guidance of a teacher, and at the lowest possible level in the organization

Figure 5 Four Rules of Toyota Production System **(Spears & Bowen, 1999)**

Development of Lean Assessment Tools

The implementation of lean tools has been analyzed repeatedly over the past forty years, (Hoss & Schwengber ten Caten, 2013) since the world first began taking notice of the principles in place at Toyota Motor Company. Over that time, researchers and practitioners have completed dozens of empirical studies (Doolen & Hacker, 2005), as well as created quantitative (Saurin, Marodin, & Ribeiro, 2011; Avari, Zulkifli, & Yusuff, 2013) and qualitative (Doolen & Hacker, 2005) assessment tools, or a combination of each (Pakdil & Leonard, 2014).

The development of many of the assessment tools is based on a belief that if the "level of leanness" of an organization can be measured as a business metric, then more companies will have successful lean transformations over time. (Avari, Zulkifli, & Yusuff, 2013; Hines, Holweg, & Rich, 2004; Van Aken, Letens, Coleman, Farris, & Goubergen, 2005) Many authors base the development of an assessment tool on the works of Shingo (1989), Womack, Jones, Roos (1990), Liker (2004), Liker & Morgan (2006), and Monden (2012) who studied the workings of the Toyota Production System directly. Other studies have chosen to test commercial methods such as the Strategos Lean assessment, Lockheed Martin Lean assessment tool, and the Baldrige Award or the Shingo Prize Model. (Taj, 2005; Izezie & Hargrove, 2009; Saurin, Marodin, & Ribeiro, 2011; Van Aken, Letens, Coleman, Farris, & Goubergen, 2005)

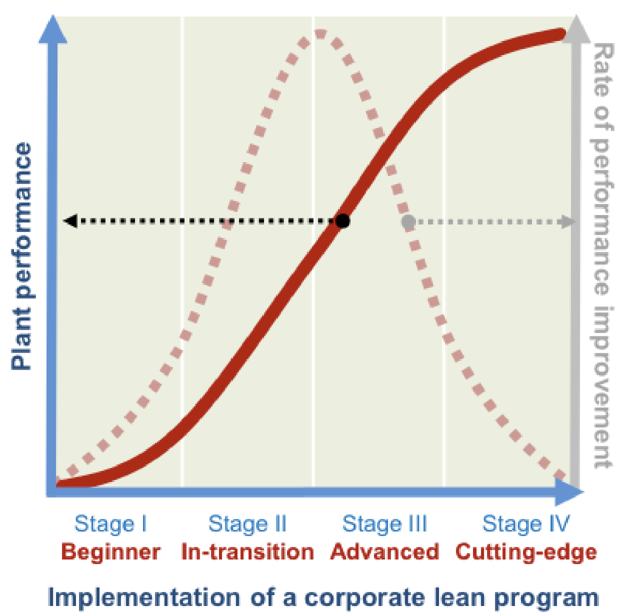

Figure 6 Performance effect of corporate lean implementation **(Netland & Ferdows, 2014b)**

The Performance Effect from Lean Implementation

The primary goals of the assessment tools are to measure the effectiveness and understand the implementation of lean manufacturing practices. In a study by Netland and Ferdows, (2014a; 2014b) the implementation of lean initiatives was evaluated compared to the effect of plant performance over time. The research indicates a four stage development process, shown in Figure 6 as Beginner, In-Transition, Advanced, and Cutting-Edge plants. This four stage process coincides with the implementation of lean tools throughout the enterprise (Hines, Holweg, & Rich, 2004). While some sources stress that the lean implementation journey is different for each process and should be free to evolve, (Netland & Ferdows, 2014a; 2014b) they still attempt to place a timeframe and definitions around implementation. Others assign a time frame to measure the progress and efficiency of the implementation as a baseline for comparison (Hines, Holweg, & Rich, 2004). As shown in Figure 6, there is a rise and fall for the rate at which improvements occur, and expected consistent increase to plant performance is unrealistic (Netland & Ferdows, 2014b). These rigid expectations often cause leadership to panic when forecasted plans are not met, and rather than determine why the implementation is not proceeding as planned, most abandon the pursuit and return to batch-and-queue systems. A key element to the implementation of lean fundamentals is the ability of managers to align expectations for improvement to the process.

Requirements for Sound Performance Metrics

The performance metrics of a business are critical information used to focus on the daily work activities, while aligning with the company's vision of the future. Many of the metrics included in the lean assessment tools are based on traditional batch-and-queue systems (Taj, 2005), while other assessments (Pakdil & Leonard, 2014) attempt to align the metrics with the principles of the Toyota Production System and the seven wastes. In his blog, Baudin (2011) discusses a corporate need to measure and evaluate all activities, as well as the risks of relying on metrics which are too easily corrupted by managers seeking to elevate department scores (Emiliani M. , Stec, Grasso, & Stodder, 2007). Traditionally, business metrics and processes have a direct effect on one another. When a business process changes, but the metric associated with it remains the same, it indicates a lack of commitment among the leadership team, as well as an improper performance assessment structure (Emiliani M. , Stec, Grasso, & Stodder, 2007).

Conditions for a Good Metric

1. Immediately understandable: no training required to understand, and value must directly relate to the real world with no manipulations
2. Workers should effect the value: Workers should know what actions will improve the value of the metric, and it should not be tied to factors out of the workers control (i.e. market price)
3. A higher value equals better business performance: The metric should directly relate the resulting score to the performance of the business
4. Data should be easy to collect: the source data should be straightforward and easy to gather
5. Metrics should have appropriate sensitivity: Values should be updated at a pace that is consistent with business improvements, and neither too fine or too broad in resolution

Figure 7 Conditions for a Good Metric **(Baudin, 2011)**

Existing Tools for Lean Process Assessment

A prevailing theme among the literature is that for a successful implementation of lean principles there is much more required than simply tools and techniques (Emiliani M. , Stec, Grasso, & Stodder, 2007; Liker, 2004; Monden, Toyota production system: An integrated approach to just-in-time, 2012; Ohno, 1988; Ohno, 2013). That is not to say however, that there are not already tools which is capable of providing a current state analysis of a process. A value stream map (Rother & Shook, 2009; Dennis, 2007) is a simple tool which is quickly able to identify the status of a process, locations of waste, production metrics such as cycle time, change over time, availability, and quality. Value stream maps are versatile and can be used in production, service, or information flow processes. This allows the same tool to be used at all levels of an organization (Dennis, 2007).

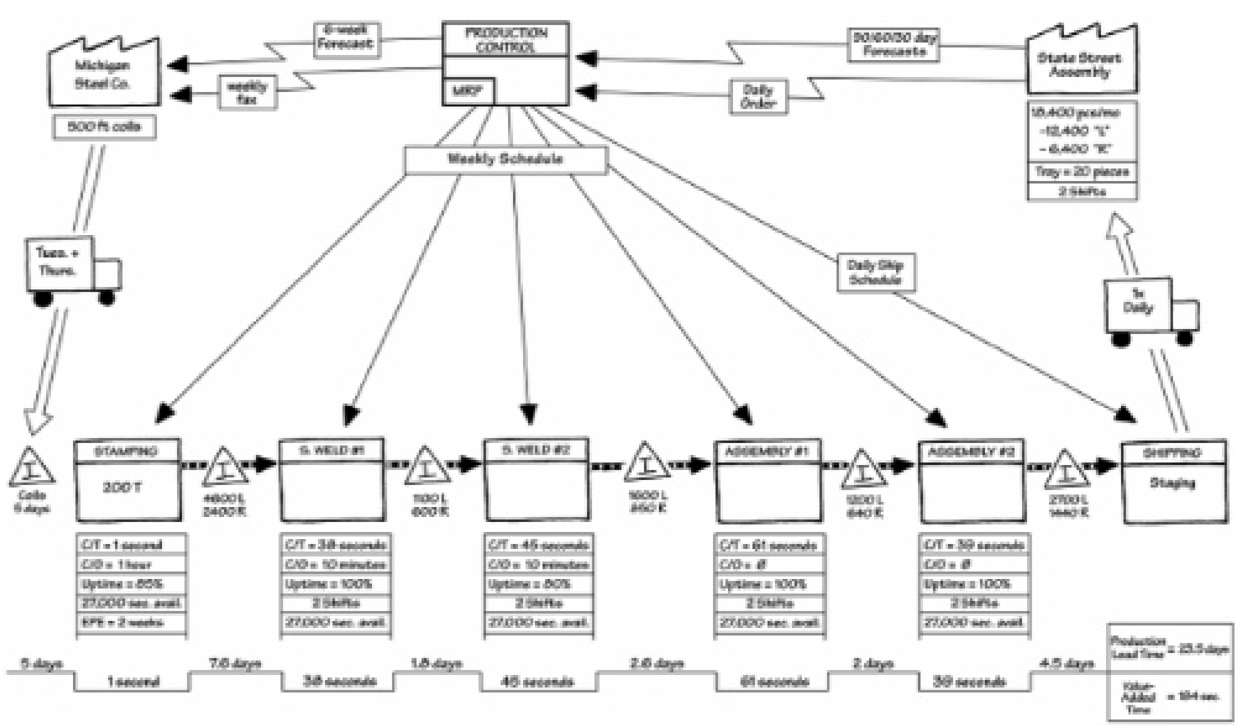

Figure 8 Value Stream Map Example **(Rother & Shook, 2009)**

Further refinement of the process can be achieved through other lean process tools. These tools are capable of evaluating the status of; the process productivity, quality, cost, delivery time, safety and morale (Dennis, 2007; Maskell, Baggaley, & Grasso, 2011), and correspond to the primary focus of the lean assessment tools being created. These measures, shown in Figure 9, exist within a lean enterprise and are capable of providing details to anyone at any level of the business down to an hour by hour interval (Maskell, Baggaley, & Grasso, 2011). By creating a set of measurements that use data which is straightforward, easily attainable, and clear to anyone in the organization, leaders can break down the silos that exist in conventional management, and begin to see the value and risk of decisions to the entire business, and not just to a single business unit.

Strategic Issues	**Strategic Measures**	**Value Stream Measures**	**Cell/Process Measures**
• Increase sales and market share • Increase cash flow • Continuous Improvement culture	• Sales per employee • Sales growth • On-time delivery • Customer satisfaction	• Sales per employee • On-time delivery • Dock-to-dock delivery • First time through • Average cost per unit • Accounts Receivable days Outstanding	• Day-by-hour production • WIP-to-SWIP • First time through • Operational Equipment Effectiveness (OEE)

Figure 9 Performance Measure Starter Set (Maskell, Baggaley, & Grasso, 2011)

Analysis / Discussion

Taiichi Ohno foresaw the dangers of improper implementation of Lean principles early on. He said "If companies can get rid of fat when they attempt to become lean, this is good. But if they lose not fat but muscle, and think they are actually slimming down, this is very dangerous thinking" (Ohno, 2013). An improper understanding of the true principles behind lean enterprise has resulted in countless failed attempts at implementation since other companies began attempting to follow the Toyota Production System model. Real lean principles, and implementation, are examples complex ideas for which there are no simple one-to-one correspondence between idea and thing (McInerny, 2004). Illogical thinking, and decision making failures on the part of leaders searching for a "path to lean" have contributed greatly to the misapplication of lean principles in the past.

A common mistake made during the decision making process has been to assume that a particular statement is true for a universal subject (McInerny, 2004). While it seems obvious that a statement which is true for one subset does not imply that the statement is true for the whole set, many leaders have assumed that the same lean tools applied favorably at one company will have the same effect at another. This is not always the case each company and process presents its own unique set of circumstances and challenges to overcome; and falls under the category of a False Assumption (McInerny, 2004), or assuming something is true without knowing it with certainty. In his book *Lean Production Simplified,* Dennis provides a quote by Garcia Lorca which states, "To suggest is to create. To define is to destroy." (Dennis, 2007) This simple philosophy is repeated throughout the history of the Toyota Production System (Ohno, 2013), as well as through the teachings of Shingijutsu USA (Emiliani, Yoshino, & Go, 2015; Wood, Herscher, & Emiliani, 2015). Taiichi Ohno was known for a technique in which he would continue to ask "What are you doing" when reviewing the work being performed at the genba. This became known as the 5-Why

Analysis and is used today as a root cause investigation tool. Ohno used this technique in order to teach his employees how to think for themselves, rather than provide the answer for them. To provide the answer would prevent his employees the opportunity to improve upon what was done, because they would have kept to what they were taught.

This technique is carried on today by modern sensei's such as Chihiro Nakao, who was one of Ohno's original students (Wood, Herscher, & Emiliani, 2015; Emiliani, Yoshino, & Go, 2015). A deeply held belief taught by sensei from Shingijutsu USA is that Kaizen of the genba toward the ideal state requires growing people and evolving knowledge (Wood, Herscher, & Emiliani, 2015). The tools taught by sensei from Shingijutsu USA are relatively simple, however the ability to think through a problem or situation to determine an ideal state is a technique that requires continued application and practice. Companies who learn the Shingijutsu-Kaizen method do not advance from basic, to intermediate and then advanced concepts based on a test, or evaluation by the consultants. Instead they continue to make improvements and learn the true nature of Kaizen, and lean, and move on naturally (Emiliani, Yoshino, & Go, 2015; Wood, Herscher, & Emiliani, 2015). In some cases, the team may take a step back to relearn basic principles, and in this way, each implementation is unique.

In their review of lean assessments in organizations, Doolen and Hacker (2005) make several illogical conclusions regarding the need for an assessment tool, and how it would be used in practice. One claim is that "the level of implementation does vary and may be related to economic, operational, or organizational factors" (Doolen & Hacker, 2005). The conclusion that implementation of lean is based on any of these factors is in direct contradiction to how the Toyota Production System was developed in the 1950's described in Figure 10.

Market conditions facing Toyota in the 1950's

1. Fragmented markets demanding many products in low volumes
2. Tough competition
3. Fixed of falling prices
4. Rapidly changing technology
5. High cost of capital

Figure 10 Market conditions facing Toyota in 1950's **(Dennis, 2007)**

For example, many of the researchers indicate that either economic factors or market conditions (Doolen & Hacker, 2005; Avari, Zulkifli, & Yusuff, 2013; Cil & Turkan, 2013) prevent successful implementation of lean. This appears logical based on the restrictions of a batch-and-queue process, but diverts attention from the fact that Toyota developed TPS in response to many of the same market conditions seen today. (Dennis, 2007; Ohno, 1988; Liker, 2004)

In order to be able to compete with the mass production methods of Ford and the other U.S. auto makers, Toyota was forced to develop a new strategy with the principle goal of reduced cost, but the principle target was reduced waste (Ohno, 1988). Similar tactics were used successfully by the Wiremold in the 1990's achieve growth with reduced costs, without using layoffs to generate profits, or hiring excess workers (Emiliani M. , Stec, Grasso, & Stodder, 2007). From the data in Table 1 of the Assessment Criteria used in the reviewed Lean Assessment tools, it is clear the majority of the authors have chosen to focus the value of the assessment of the quantity of lean tools. In his review of the Toyota Production System, Shigeo Shingo (1989) outlines its basic features, and lists first and foremost targeted cost reduction via the thorough elimination of waste. In this way, the leading indicator is waste, and the resultant is cost. From the assessments reviewed, 40% evaluate costs directly, while only 20% address the elimination of waste. Further, it shows that the authors of the assessments have taken the tools of Lean and focused on them; most notably

JIT delivery, Set-Up Time reduction (SMED) and Inventory reduction (Kanban). While JIT, SMED, Kanban, along with other tools such as 5S, visual controls, and continuous improvement (Kaizen) are important tools, they are all separate entities (Shingo, 1989). An assessment tool that is aimed at determining the "leanness" of an organization undertaking a transformation that does not address the waste in the system, is missing the fundamental focus of lean.

Percentage of Tools Evaluating Criteria	Assessment Criteria
45%	Quality, JIT Delivery
40%	Cost, Set Up Time
35%	Inventory, Employee Involvement, Pull System
30%	Time, Cellular Manufacturing, Visual Management, Supplier Issues, Condition and Maintenance of Equipment and Tools, Processess
25%	Continuous Improvement, Multifunctional Teams, Customer Issues, Scheduling System
20%	Elimination of Waste, Work Force Management
15%	Safety, Environment Cleanliness and Order, Movement of Materials, Flow
10%	Productivity, Market Share, Capacity, Lean Practices, Various Waste, Product Design, Standardization
5%	Product Value, Decentralized Responsibilities, Integrated Functions, Vertical Information Systems, Lean Change Strategy/Sustainability, Culture, Investment Priorities, Mangement of Complexity and Variability, Shop-floor Management, Controlled Processes, Flexibility, Use of Space

Table 1 Criteria breakdown in lean assessment tools. Source material **(Pakdil & Leonard, 2014)**

Another common element among the lean assessment tools is the use of a progressive grading system used to rank the company's progress on the lean journey (Avari, Zulkifli, & Yusuff, 2013; Cil & Turkan, 2013; Doolen & Hacker, 2005; Izezie & Hargrove, 2009). It is human nature for a manager to grade themselves higher for fear of retribution, and in the command-and-control style of leadership, managers learn how to report or adjust metrics to make their group look better (Emiliani, 2000). For this reason, many of the assessments contain faulty data, and should not be trusted (Wood, Herscher, & Emiliani, 2015). Furthermore, the use of a grading system (i.e. 1-5) implies that there in an ideal state, or end to the lean journey, and relies on the management team to respond in an honest manner. Toyota had been working on developing its production system for twenty-five years before it became known, and have continued to make improvements to this day (Ohno, 1988) (Ohno, 2013) (Shingo, 1989).

Basic Fundamental of Toyota Production System

- Targets cost reduction via the thorough elimination of waste
- Eliminates overproduction through the notion of non-stock and achieves labor cost reduction via minimal manpower
- Reduces production cycles drastically through the use of SMED to achieve non-stock by carrying out small lot production, equalization, synchronization, and one-piece flow
- Thinks of demand in terms of order-based production
- Adheres consistently to the idea that the quantity produced should be the quantity ordered

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Figure 11 Basic Fundamentals of TPS (Shingo, 1989; Monden, 1983)

This type of thinking is counter to the principle teachings of Kaizen essential to the elimination of waste in the process. A manager who communicates that there is nothing wrong, or nothing to be improved, in there process is either lying or does not know the system well enough to answer (Emiliani, Yoshino, & Go, 2015). Either way the manager does not understand the principles of lean. Ultimately, a lean assessment tool that relies on a subjective metric, results in a manager who manages to a metric, rather than reality, ignores the root causes of waste in the system, and only treats a symptom.

Lean assessment tools create a risk to the successful implementation of lean by focusing on cost as a driver of the process rather than the result of the process. While the goal of the Toyota

Production System, and lean enterprise, is cost reduction, it is accomplished through the elimination of waste within the process. Company's looking to increase profits in a buyer's market have two options; either increase the selling price of the product, or eliminate cost from the process. Through repeated practice of the basic concepts of Kaizen, companies will see the effect in the form of cost reduction if done in the right way. The three basic steps are to assure 100% quality in the product sold, only produce the amount necessary now, and make it just in time for the customer.

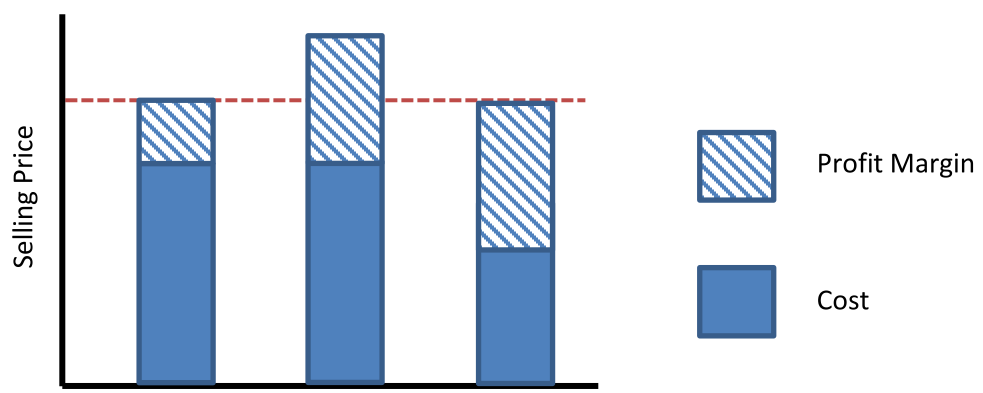

Figure **12** Illustration of profit growth through cost reduction (Dennis, 2007)

By improving the genba, which is where all profits are generated, companies will be able to transform the business and generate growth opportunity (Emiliani, Yoshino, & Go, 2015). The value of the improvements resulting from Kaizen, can be tracked and evaluated according to metrics that show Operational, Capacity, and Financial improvements using value stream score cards (Maskell, Baggaley, & Grasso, 2011).

In his study of the Toyota Production System, Shigeo Shingo describes the conflict surrounding man power cost reduction:

> “To improve operations, the Toyota production system focuses on manpower cost reductions. By comparison, relatively little emphasis is placed on raising the operating rates even though they are, along with man, the primary agents of production.
>
> The reason for this is straightforward: For a given period of time, the loss will be about five times greater for idle workers than for idle machines. Moreover, Toyota realized that no matter how low equipment operating rates might be, for the purpose of cost reduction, it was more effective to concentrate on human labor cost. Failure to grasp this point clearly and keep it in mind may well lead to a misunderstanding of the exact role manpower cost reduction plays in the Toyota Production System.” (Shingo, 1989)

By applying the focus of business managers on the bottom line costs, and not the waste inherent within the process, the lean assessment tools are diverting the focus of the managers away from the root cause, and to a symptom of the problem. From the data in Table 1, the assessment tools contain review of Employee Involvement, Multifunctional Teams, and work force management, but none assess the businesses willingness to not use continuous improvement as a head count reduction tool, ignoring the respect for principle pillar of lean management. The goal of cost reduction should be met by addressing the wastes of time, quantity and distance while simultaneously maintaining quality control, quality assurance and respect for people. (Emiliani, Yoshino, & Go, 2015) Employees that believe that they will lose their job if they participate in Kaizen will not give their best effort, and will not support the long term implementation of the lean principles. It is for this reason that Art Byrne offered a qualified job guarantee during the transformation at the Wiremold Company in the 1990’s (Emiliani M. , Stec, Grasso, & Stodder, 2007). This guaranteed that no employee would be laid off due to productivity improvements resulting from Kaizen. By retraining and redeploying employees displaced by process improvements, the Wiremold Company was able to grow and prosper without resorting to layoffs to increase earnings.

In their paper, "Assessing the Maturity and Effectiveness of Enterprise Performance Measurement Systems", Van Aken et al. insist that maturity assessments are tools which generate useful and actionable feedback for leadership. In addition, the tool can be used longitudinally to track progress in performance measurement system effectiveness (Van Aken, Letens, Coleman, Farris, & Goubergen, 2005). While the need for useful and actionable feedback, as well as the ability to track performance over time are important, the requirement of a specific lean assessment tool to generate this information is a statement of value, rather than a statement of fact, as well as a red herring and a false dilemma (McInerny, 2004). In an attempt to convince the reader that the assessment tool is necessary, the authors are appealing to human nature, and the need for a report to provide an answer, stating that an assessment is the means to that end. In addition, they are failing to include the fact that within a lean enterprise system exists the means of generating useful and actionable feedback, as well as the ability to track progress in system effectiveness.

Within a lean enterprise, tools are used to evaluate, measure, and develop strategic plans based on objective evidence readily available within the organization. These tools fall under the category of Lean Accounting, and although some elements deal with cost, it is not strictly a financial tool as the name would imply. Significant implementation issues can arise if the proper system for evaluating is not used (Camacho-Minano, Moyano-Fuentes, & Sacristan-Diaz, 2012), for example using cost accounting to evaluate a lean enterprise (Emiliani M. , Stec, Grasso, & Stodder, 2007) (Maskell, Baggaley, & Grasso, 2011).

The use of lean accounting principles have significant benefits to using standard cost accounting principles, including providing clearer information for decision making, identifying potential financial benefits of lean improvement initiatives, and focuses the business strategies on efforts that will realize those benefits (Maskell, Baggaley, & Grasso, 2011). Many of the wasteful practices seen in cost accounting are also apparent in the lean assessment tools developed so far. For example, both require large amounts of unnecessary work to gather and analyze data, which produce reports that do no correlate directly to the business, only serving to generate additional non-value added tasks (Maskell, Baggaley, & Grasso, 2011).

In contrast, Lean Performance measures occur at three specific levels of the organization; with cell measures, value stream measures, and strategic measures. These measures are objective data that is readily available and provides a clear picture of how the cell, value stream, and business is operating. (Maskell, Baggaley, & Grasso, 2011) In stark contrast to standard cost accounting information which is based on forecasts, variance budget targets, and countless transactions, the data from lean accounting methods is available on an hour by hour basis for managers on the floor, and can be relayed directly to any level of the organization. Since the metrics are uniform among all functions of the business, it is clear to anyone who sees it how the business is doing (Maskell, Baggaley, & Grasso, 2011). Furthermore, this information can be used during the Hoshin Kanri (Strategic Planning) process, is critical to communicating strategic plans throughout the organization, and is saved in a historical "playbook" (Dennis, 2007) to be used to evaluate the course of the business, past risks, as well as successes over time (Maskell, Baggaley, & Grasso, 2011). An example of a value stream scorecard can be found in the Appendix.

It is important to use the proper evaluation system when auditing any system. Standard cost accounting promotes non-value added behaviors and waste such as focus on utilization of equipment, the amount of overhead absorbed by production, and personal efficiency of workers. Maximization of these metrics requires latch batch sizes, fewer change overs and increased finished goods inventory (Maskell, Baggaley, & Grasso, 2011). Each of these are non-lean behaviors, and if the lean initiatives set in place are successful, will show a negative result in the financial numbers over time. The continued use of cost accounting during a lean transformation will provide leadership with a distorted view of the business, since many of the ways cost accounting metrics are managed (high inventory, large batch sizes, absorption) are eliminated as waste in a lean enterprise. Similarly, using a lean assessment tool, which directs the focus of the business away from what is happening, and instead focuses on the types and quantities of tools being used, will not provide valuable insight into the state of the process.

A reoccurring element in the lean assessment tools reviewed is the disconnection of the evaluation by managers and the genba. For example, many focus on the quantity of tools (5S, SMED, Kanban, etc.) being utilized, or the number of manufacturing cells, however most of the data collected is subjective to the employee filling out the survey, and does not require a trip to where the work actually takes place. A common phrase of Chihiro Nakao is “Charts lie and people lie”, to which he is illustrating the philosophy of Go See for yourself, or go to the genba (Wood, Herscher, & Emiliani, 2015). By creating a survey to assess the “leanness” of a process that does not require the manager to be at the place of work, the authors have violated one of the main principles of the Toyota Production System that was most valued by Taiichi Ohno, that of Go See (Ohno, 1988)

The lean assessment tools serve to maintain the status quo set up in traditional command leadership. An example of this are the multiple “Lean” awards which are presented annually to companies who meet a certain criteria. These include the Shingo Prize, The Lean Enterprise Model, and the Baldridge Award among others (Saurin, Marodin, & Ribeiro, 2011). Each of these presents a company with a list of criteria to meet in an attempt to win a prize. However, lean is more than the application of tools, it is a philosophical mindset and way of learning and developing employees. The prizes award and emphasize the existence of the practices more than the long term results (Saurin, Marodin, & Ribeiro, 2011). Similarly, lean assessment tools provide managers with a list of criteria, or metrics, to meet and direct their direct reports to meet the metrics. Often this direction is given with the message "I don't care how you do it, just do it." This is another clear example of disconnect between levels and shows a lack of regard for the employees by managers (Dennis, 2007). This type of leadership creates poor data from surveys by employees afraid to upset their manager, or bring to light problems with the process.

The assessment model developed by Anvari, Zulkifli and Yusuff (2013) attempts to measure the value of influence of lean attributes in manufacturing systems by using "fuzzy membership functions" to calculate a lean score. This is then used by managers to get a "real insight" into the leanness of a process (Avari, Zulkifli, & Yusuff, 2013) This is a clear example of conventional management techniques found in batch-and-queue systems in which the managers never go to the place of work to see what is happening, instead opting to make decisions based solely on subjective data.

Lean Implementation

As with any system, the implementation of Kaizen, and lean principles requires a set of standard work. In order for there to be Kaizen, there must first be standard work (Ohno, 1988; Ohno, 2013; Emiliani, Yoshino, & Go, 2015). Once the initial state is observed and documented using the three tools of standard work; The Standardized Production Capacity Sheet, the Standard Work Combination Sheet, and the Standard Work Sheet, waste can begin to be uncovered and eliminated from the process. Kaizen then occurs with the output of new standard work, and then the continued identification and elimination of waste (Emiliani, Yoshino, & Go, 2015). In this manner, there is no need for any other tools to determine the "leanness" of a process. By always focusing on the future state and elimination of waste, a process will continue become more efficient, and reduce cost for the business. This level of focus requires the long-term commitment of leadership, managers, and workers at the genba. Without this commitment, the application of the tools is only an exercise that will be abandoned in favor of a return to the perceived comfort of batch-and-queue processing. For many struggling to move beyond the requirements of convention management styles, this may appear to be an overly simplified solution, however this is the true heart of Kaizen, and lean. To break any process down into the fewest steps required, with the least amount of waste.

Conclusions

Since the world began taking notice of the new production system that had been developed at Toyota Motor Company, scholars and business leaders have been attempting to replicate similar results. At first this occurred primarily within manufacturing, but has since expanded into what is known as Lean Enterprise, and is now applicable to any process. Although it is widely written about by practitioners such as Ohno (1988; 2013), Monden (1983; 2012), Shingo (1989), as well as in the research of Emiliani et. al (2007), and the philosophy of Shingijutsu USA (Emiliani, Yoshino, & Go, 2015; Wood, Herscher, & Emiliani, 2015), the most difficult element of successful lean implementation outside of Toyota has been the understanding of the respect for people principle required to ensure long-term success. By attempting to continue to treat employees in the command and conquer style common in batch-and-queue processing, leaders have not been able to let go of what they have been taught in order to embrace the full philosophy of lean enterprise. Rationalizing false metrics, maintaining the status quo, and utilizing the tools of kaizen as a headcount reduction opportunity have led to the misrepresentation of lean principles, and inability for the majority of companies to achieve a successful lean transformation. The use of lean maturity assessments to determine the "leanness" of an organization are a symptom of a batch-and-queue process based on unknown forecast, rather than just-in-time production. Utilization of the existing tools of lean enterprise, and a never ending focus on waste reduction at the place of work will provide real data for strategic decision making (the mountain), value stream (the forest) and process improvements (the tree) (Emiliani, Yoshino, & Go, 2015). The future of lean enterprise is based on a return to the fundamental principles of Standard Work, Flow Production, and Kaizen while moving away from the hidden cost and waste of batch-and-queue processing with standard cost accounting. Once an organization is mature enough to be able to perform a maturity assessment, its leaders will realize that they do not need one.

Works Cited

Avari, A., Zulkifli, N., & Yusuff, R. M. (2013). A dynamic modeling to measure lean performance within lean attributes. *International Journal of Manufacturing Technology, 66*, 663-677. doi:10.1007/s00170-012-4356-0

Ballé, M., & Jones, D. (2014, Nov 20). *What is the role of a sensei in a lean organizatin.* Retrieved Nov 23, 2014, from Planet Lean: http://www.planet-lean.com/what-is-the-role-of-a-sensei-in-a-lean-organization

Baudin, M. (2011). *The staying power of bad metrics.* Retrieved Nov 25, 2014, from Michel Baudin's Blog: http://michelbaudin.com/2011/10/28/the-staying-power-of-bad-metrics/

Camacho-Minano, M.-d.-M., Moyano-Fuentes, J., & Sacristan-Diaz, M. (2012, May 08). What can we learn from the evolution of research on lean management assessment? *International Journal of Production Research, 51*(4), 1098-1116. doi:10.1080/00207543.2012.677550

Chakraborty, S., & Ankiah, B. (1989). Assessment of manufacturing system reliability: A case study. *The Journal of the Operational Research Society, 40*(1), 55-63. Retrieved from http://www.jstor.org/stable/2583077

Cil, I., & Turkan, Y. S. (2013). An ANP-based assessment model for lean enterprise transformation. *International Journal for Advanced Manufacturing Technology, 64*, 1113-1130. doi:10/1007/s00170-012-4047-x

Columbus, L. (2008). Best practices in lean manufacturing: The migration to a lean global enterprise [White Paper]. Cincinnati, OH: Cincom Manufacturing Business Solutions.

Dennis, P. (2007). *Lean production simplified* (2nd ed.). Boca Raton, FL: Taylor & Francis.

Dentz, J., Nahmens, I., & Mullens, M. (2009). Applying lean production in factory homebuilding. *Cityscape, 11*(1), 81-104. Retrieved from http://www.jstor.org/stable/20868691

Dimancescu, D., Hines, P., & Rich, N. (1997). *The lean enterprise.* New York, NY: AMACOM.

Doolen, T. L., & Hacker, M. E. (2005). A review of lean assessment in organizations: An exploratory study of lean practices by electronics manufacturers. *Journal of Manufacturing Systems, 24*, 55-67. Retrieved from http://files.ferraz8.webnode.com/200000075-533585528b.Artigo.pdf

D'Souza, D. E., & Williams, F. P. (200). Appropriateness of the stakeholder approach to measuring manufacturing performance. *Journal of Managerial Issues, 12*(2), 227-246. Retrieved from http://www.jstor.org/stable/40604306

Emiliani (Director). (2010). *Frank George Woolard: Forgotten pioneer of flow production* [Motion Picture]. Retrieved from www.bobemiliani.com

Emiliani, B. (2000). The false promise of "what gets measured gets managed". *Management Decision, 38*(9), 612-615. doi:10.1108/00251740010694317

Emiliani, B., Yoshino, K., & Go, R. (2015). *Kaizen Forever: Teachings of Chihiro Nakao.* Wethersfield, CT: The CLBM, LLC.

Emiliani, M. L. (2013). *The future of lean.* Retrieved Nov 23, 2014, from bobemiliani Innovative Lean Leadership: http://www.bobemiliani.com/the-future-of-lean/

Emiliani, M. L., & Stec, D. J. (2004). Leaders lost in transformation. *Leadership & Organization Development Journal, 26*(5), 370-387.

Emiliani, M., Stec, D. J., Grasso, L., & Stodder, J. (2007). *Better thinking, better results: Case study and analysis of an enterprise-wide lean transformation* (2nd ed.). Wethersfield, CT: The Center for Lean Business Management, LLC.

Ford, H. (1988). *Today and Tomorrow* (Special ed.). Cambridge, MA: Productivity Press.

Gajewski, M. (2014). *Evolution of the "Respect for People" Principle in Progressive Management.* New Britain, CT.

Goodman, S. (2014, Apr 22). *Prof. Steven Goodman on meta-research and METRICS*. Retrieved Nov 23, 2014, from YouTube: http://www.youtube.com/watch?v=sLmQxDOLShA

Hines, P., Holweg, M., & Rich, N. (2004). Learning to evolve: A review of contemporary lean thinking. *International Journal of Operations & Production Management, 24*(10), 994-1011. doi:10.1108/01443570410558049

Hoss, M., & Schwengber ten Caten, C. (2013). Lean schools of thought. *International Journal of Production Research, 51*(11), 3270-3282. doi:10.1080/00207543.2012.762130

Izezie, D., & Hargrove, S. K. (2009). *Applying lean assessment tools at a Maryland manufacturing company.* Retrieved Nov 23, 2014, from American Society for Engineering Education: https://www.asee.org/documents/sections/middle-atlantic/spring-2009/Applying-Lean-Assessment-Tools-at-a-Maryland-Manufacturing-Company.pdf

Lewin, A. Y., & Minton, J. W. (1986). Determining organizational effectiveness; Another look, and an agenda for research. *Management Sciences, 32*(5), 514-538. Retrieved from http://www.jstor.org/stable/2631844

Liker, J. K. (2004). *The Toyota way.* New York, NY: McGraw-Hill.

Liker, J. K., & Morgan, J. M. (2006). The Toyota way in services: The case of lean product development. *Academy of Management Perspectives, 20*(2), 5-20. Retrieved from http://www.jstor.org/stable/4166229

Maskell, B., Baggaley, B., & Grasso, L. (2011). *Practical Lean Accounting: A Proven System for Measuring and Managing the Lean Enterprise* (2nd ed.). Boca Raton, FL: CRC Press.

McDonald, T., Ellis, K. P., Van Aken, E. M., & Koelling, C. P. (2009). Development and application of a worker assignment model to evaluate a lean manufacturing cell. *International Journal of Production Research, 47*, 2427-2447. doi:10/1080/00207540701570174

McInerny, D. (2004). *Being Logical: A Guide to Good Thinking.* New York: Random House.

Mehri, D. (2006). The darker side of lean: An insider's perspective on the realities of the Toyota production system. *Academy of Management Perspectives, 20*(2), 21-42. Retrieved from http://www.jstor.org/stable/4166230

Monden, Y. (1983). *Toyota Production System: Practical Approach to Production Management* (1st ed.). New York: Industrial Engineeering and Management Press.

Monden, Y. (2012). *Toyota production system: An integrated approach to just-in-time* (4th ed.). New York, NY: Taylor & Francis.

Netland, T. H., & Ferdows, K. (2014b, Aug 19). *Corporate world: How does lean work in large organizations?* Retrieved Nov 23, 2014, from Planet-Lean: http://www.planet-lean.com/corporate-world-how-does-lean-work-in-large-organizations

Netland, T., & Ferdows, K. (2014a). What to expect from corporate lean programs. *MIT Sloan Management Review, 55*(4), 83-89. Retrieved Nov 23, 2014, from http://0-search.proquest.com.www.consuls.org/docview/1543709930?accountid=9970

Ohno, T. (1988). *Toyota production system: Beyond large-scale production.* (Productivity Press, Trans.) New York, NY: Productivity Press.

Ohno, T. (2013). *Workplace management* (Special ed.). (J. Miller, Trans.) White Plains: McGraw-Hill Companies.

Pakdil, F., & Leonard, K. M. (2014). Criteria for a lean organisation: Development of a lean assessment tool. *International Journal of Production Research, 52*(15), 4587-4607. doi:10.1080/00207543.2013.879614

Rohloff, M. (2010). Advances in business process management implementation based on a maturity assessment and best practice exchange. *Information Systems and e-Business Management, 9*, 383-403. doi:10/1007/s10257-010-0137-1

Rother, M., & Shook, J. (2009). *Learning to see* (1.4 ed.). Cambridge, MA: Lean Enterprise Instiiute Inc.

Ruffa, S. A. (2011). *The going lean fieldbook.* New York, NY: AMACOM.

Saurin, T. A., Marodin, G. A., & Ribeiro, J. L. (2011). A framework for assessing the use of lean production practices in manufacturing cells. *International Journal of Production Research, 49*, 3211-3230. doi:10.1080/00207543.2010.482567

Shingo, S. (1989). *A study of the Toyota production system* (Revised ed.). (A. P. Dillon, Trans.) Cambridge, MA: Productivity Press.

Spears, S. J. (2004). Learning to lead at Toyota. Watertown, MA: Harvard Business Publishing. Retrieved from https://hbr.org/2004/05/learning-to-lead-at-toyota

Spears, S. J., & Bowen, H. K. (1999). Decoding the DNA of the Toyota production system. Watertown, MA: Harvard Business Publishing.

Steel, A. (2014, Nov 17). *Auditing the UK government's performance and its adoption of lean management: The national audit office's assessment framework.* Retrieved Nov 19, 2014, from Planet-Lean: http://planet-lean.com/auditing-the-uk-governments-performance-and-its-adoption-of-lean-management-ideas-the-national-audit-offices-assessment-framework

Taj, S. (2005). Applying lean assessment tools in Chinese hi-tech industries. *Management Decision, 43*(4), 628-643. doi:10.1108/00251740510593602

Taylor, F. W. (2010). *The principles of scientific management.* USA: ReadaClassic.com (Original work published 1911).

Van Aken, E. M., Letens, G., Coleman, G. D., Farris, J., & Goubergen, D. V. (2005). Assessing maturity and effectivenss of enterprise performance measurement systems. *International Journal of Productivity and Performance Measurement, 54*(5/6), 400-418. doi:10.1108/17410400510604557

White, R. E., Pearsons, J. N., & Wilson, J. R. (1999). JIT manufacturing: A survey of implementations in small and large U.S. manufacturers. *Management Sciences, 45*(1), 1-15. Retrieved from http://www.jstor.org/stable/2634918

Womack, J. P., & Jones, D. T. (2003). *Lean thinking* (2nd ed.). New York, NY: Free Press.

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The machine that changed the world: The story of lean production.* New York, NY: HarperCollins.

Wood, R., Herscher, M., & Emiliani, B. (2015). *Shingijutsu-Kaizen: The Art of Discovery and Learning.* Wethersfield, CT: The Center for Lean Business Management, LLC.

Woollard, F. G., & Emiliani, M. L. (2009). *Principles of mass and flow production* (Special ed.). Wethersfield, CT: The Center for Lean Business Management, LLC.

References

Chakraborty, S., & Ankiah, B. (1989). Assessment of manufacturing system reliability: A case study. *The Journal of the Operational Research Society, 40*(1), 55-63. Retrieved from http://www.jstor.org/stable/2583077

Columbus, L. (2008). Best practices in lean manufacturing: The migration to a lean global enterprise [White Paper]. Cincinnati, OH: Cincom Manufacturing Business Solutions.

Dentz, J., Nahmens, I., & Mullens, M. (2009). Applying lean production in factory homebuilding. *Cityscape, 11*(1), 81-104. Retrieved from http://www.jstor.org/stable/20868691

Dimancescu, D., Hines, P., & Rich, N. (1997). *The lean enterprise.* New York, NY: AMACOM.

Emiliani, M. L., & Stec, D. J. (2004). Leaders lost in transformation. *Leadership & Organization Development Journal, 26*(5), 370-387.

Lewin, A. Y., & Minton, J. W. (1986). Determining organizational effectiveness; Another look, and an agenda for research. *Management Sciences, 32*(5), 514-538. Retrieved from http://www.jstor.org/stable/2631844

McDonald, T., Ellis, K. P., Van Aken, E. M., & Koelling, C. P. (2009). Development and application of a worker assignment model to evaluate a lean manufacturing cell. *International Journal of Production Research, 47*, 2427-2447. doi:10/1080/00207540701570174

Mehri, D. (2006). The darker side of lean: An insider's perspective on the realities of the Toyota production system. *Academy of Management Perspectives, 20*(2), 21-42. Retrieved from http://www.jstor.org/stable/4166230

Rohloff, M. (2010). Advances in business process management implementation based on a maturity assessment and best practice exchange. *Information Systems and e-Business Management, 9*, 383-403. doi:10/1007/s10257-010-0137-1

Ruffa, S. A. (2011). *The going lean fieldbook.* New York, NY: AMACOM.

Steel, A. (2014, Nov 17). *Auditing the UK government's performance and its adoption of lean management: The national audit office's assessment framework.* Retrieved Nov 19, 2014, from Planet-Lean: http://planet-lean.com/auditing-the-uk-governments-performance-and-its-adoption-of-lean-management-ideas-the-national-audit-offices-assessment-framework

White, R. E., Pearsons, J. N., & Wilson, J. R. (1999). JIT manufacturing: A survey of implementations in small and large U.S. manufacturers. *Management Sciences, 45*(1), 1-15. Retrieved from http://www.jstor.org/stable/2634918

Womack, J. P., & Jones, D. T. (2003). *Lean thinking* (2nd ed.). New York, NY: Free Press.

Appendix: Lean Assessment Study Matrix

Study Authors	Quality	Cost	Time	JIT delivery	Inventory	Cellular Manufacturing	Employee involvement	Set up time	Product value	Safety	Productivity	Market Share	Capacity	Elimination of Waste	Continuous Improvement	Pull System	Multifunctional teams	Decentralized responsibilities	Integrated functions	Vertical information systems	Visual management	Lean change strategy and sustainability	Culture
Karlsson and Åhlström (1996)	X		X	X				X						X	X	X	X	X	X	X			
James-Moore and Gibbons (1997)														X									
Panizzolo (1998)				X		X		X								X					X		
Maskell (2000)		X																					
Allen, Robinson, and Stewart (2001)	X	X								X	X												
Goodson (2002)	X			X	X		X			X							X				X		
Shah and Ward (2003)	X			X		X		X							X	X	X						
Doolen and Hacker (2005)		X	X			X	X	X								X	X				X		
Taj (2005)					X		X														X		
Shileds (2006)					X																		
Shah and Ward (2007)				X			X	X								X							
Bayou and De Corvin (2008)		X			X							X											
Wan and Chen (2008)		X	X						X														
Fullerton and Wempe (2009)	X					X	X	X															
Petterson (2009)			X	X	X	X	X	X						X	X	X	X				X		
Searcy (2009)	X	X			X						X		X										
Singh et al. (2010)																							
Behrouzi and Wong (2011)	X	X	X	X																			
Bhasin (2011)	X			X						X					X						X	X	X
Pakdil and Leonard (2014)	X	X	X	X	X	X	X	X				X	X	X	X	X							

Table 2 Quantitative and Qualitative Lean Assessment Studies **(Pakdil & Leonard, 2014)**

Table 2 Continued

Study Authors	Supplier Issues	Investment Priorities	Lean Practices	Various Waste	Customer Issues	Environment, Cleanliness, and Order	Scheduling System	Movment of Materials	Condition and Maintenance of Equipment and Tools	Management of Complexity and Variability	Product Design	Work Force Management	Shop-floor Management	Flow	Controlled Processes	Flexibility	Processes	Standardization	Use of Space
Karlsson and Åhlström (1996)																			
James-Moore and Gibbons (1997)												X			X	X	X		
Panizzolo (1998)	X				X	X			X			X					X		
Maskell (2000)																			
Allen, Robinson, and Stewart (2001)																			
Goodson (2002)					X	X	X	X		X									X
Shah and Ward (2003)									X					X					
Doolen and Hacker (2005)	X				X		X		X		X						X		
Taj (2005)	X					X		X	X								X		
Shileds (2006)																			
Shah and Ward (2007)									X					X					
Bayou and De Corvin (2008)																			
Wan and Chen (2008)																			
Fullerton and Wempe (2009)																			
Petterson (2009)	X						X					X						X	
Searcy (2009)																			
Singh et al. (2010)	X	X	X	X	X														
Behrouzi and Wong (2011)																			
Bhasin (2011)			X				X										X		
Pakdil and Leonard (2014)																			

Appendix: Sample Value Stream Box Score

		Current State	**Future State**	**Long-Term Future State**
Operational	Sales per Person	$131,429	$131,429	$235,936
	On-Time Delivery	82%	96%	96%
	Dock-to-Dock Time	23.60	4.50	4.50
	First Time Through	90%	90%	90%
	Average Cost per Unit	$4.94	$4.94	$4.73
	AR Days Outstanding	60	30	30
Capacity	Productive Capacity	25%	22%	29%
	Non-productive Capacity	30%	8%	11%
	Available Capacity	45%	70%	60%
Financial	Annual Revenue	$1,840,000	$1,840,000	$3,303,100
	Annual Material Cost	$772,800	$772,800	$986,832
	Annual conversion cost	$317,752	$317,752	$317,752
	Value Stream Profit	$749,448	$749,448	$1,998,516
	Value stream cash flow	$749,448	$1,818,672	$3,062,740

Table 3 Sample Value Stream Box Score