2019

A Quantitative Evaluation of the Productivity of the Mercedes-Benz Production System

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2019

Abstract

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MBA, Webster University, 2005

BS, South Carolina State University, 2003

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Applied Management and Decision Sciences

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May 2019

Abstract

Productivity of automotive manufacturing production systems have been an area of study among researchers since the industrial revolution. Automotive manufacturing production systems that are implemented properly increase productivity in production environments. Researchers have demonstrated that productivity can be improved through modeling the Toyota production system. However, researchers have not established how implementing Mercedes Benz production system (MBPS) impacted Mercedes-Benz cars' productivity between 1999 and 2017. The purpose of this quantitative research study was to examine the effect of implementing the Mercedes-Benz Production System (MBPS). A survey was administered to 35 Mercedes-Benz employees that consisted of operation managers, plant managers, manufacturing engineers, and shop workers. The study used Spearman's correlations to analyze the strength of the associations between the dependent variable of productivity and the three independent variables of cycle-time variation, employee-headcount variation, and key performance indicators. The results showed no statistically significant relationship, supporting that implementing the MBPS was not sufficient enough to reject the null hypothesis the research questions. The social change implications for this research may promote positive social change by its emphasis on the implementation of manufacturing production systems. Such implementations may then stimulate increased economic efficiencies, quality, and profitability for society.

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Dedication

This dissertation is dedicated to my loving wife, LaShonda Shaw; my loving daughters, Destiny S. and Madison E. Shaw; my parents, Elijah and Berneice T. Shaw; my grandmother, Mattie B. Thomas (deceased); my uncle and godfather, Lewis Thomas; and my siblings, Elijah Jr., Maurice, Marcus, and Bryan Shaw. A spirit of excellence, hard work, ethics, and persistent perseverance has encompassed the essence of our family's values and household. Our parents always encouraged each of us in our own special way to ensure the attainment of our goals and a spiritual foundation in Jesus Christ My Lord. As a person who believes in and practices servant leadership, I pray that my body of work will grow and contribute to the advancement of lives in my industry globally.

Acknowledgments

I would like to acknowledge the leadership, encouragement, and support provided by my dissertation committee: Dr. Jeffrey Prinster, Dr. Raghu Korrapati, and Dr. Bharat Thakkar. I especially thank the chair of my committee, Dr. Jeffrey Prinster, for his fortitude, inspiration, and wisdom as a beacon for the PhD experience and as my mentor throughout several years at Walden University.

I would like to also thank Dr. William Brent and Dr. Godwin Igein for contributing to my dissertation.

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Chapter 1: Introduction to the Study

The topic of this quantitative, comparative study was an analysis of the performance of the Mercedes-Benz Production System (MBPS) after its implementation. The study was necessary because most of automotive manufacturing companies experience issues in effectively implementing quality production systems. Since the early 1900s, improper implementation of these systems has caused problems—product defects, missed production goals, and employee dissatisfaction—for automobile manufacturing companies around the world (Miina, 2013). If implemented properly, quality production systems can improve the following performance indicators: production productivity, lean processes, cycle-time variation, and throughput (Bagozzi, 2012). This study has positive social change implications. It could mitigate ergonomic risks; improve health and safety issues; and sustain productivity locally, nationally, and globally. In this research study I evaluated the impact of MBPS on the productivity of Mercedes-Benz cars using the principles of the Toyota Production System (TPS). The premise of this study was to evaluate the independent variables of cycle-time variation, employee-headcount variation, and key performance indicators (KPIs) by measuring the causal impact on the dependent variable of productivity after implementing the MBPS.

This study used a quantitative research design to fill the gap in current research reviewing Mercedes-Benz cars' productivity between 1999 and 2017. The gap was how the independent variables of cycle-time variation, employee-headcount variation, and KPIs affected the dependent variable of productivity after implementation of the MBPS. The outcome of the study showed inconclusive impact on productivity for Mercedes-

Benz cars at the $p = .05$ level. The p-value in this research study was calculated using null distribution and related to the probability of the right side of the test statistic. This test determined how far off the test statistic was and allowed me to measure the right-hand tail of the null distribution. Regression analysis was proposed for completing this research study, but I used nonparametric Spearman correlations. The plan of the study was to seek current Mercedes-Benz cars employees who experienced the effects of MBPS implementation. Mercedes-Benz cars was a part of the Daimler Group portfolio that consisted of Mercedes-Benz cars, Daimler trucks, Mercedes-Benz vans, Daimler buses, and Daimler Financial Services.

The broad focus of this research effort was to understand the success of the implementation of MBPS within Mercedes-Benz cars in 1999 and the impact on Mercedes-Benz cars' productivity. The pivotal element in the study was the evaluation of MBPS implementation. The study involved examining the dependent variable, productivity, from 1999 to 2017 after the implementing the MBPS. Though the subject under study was MBPS productivity, it was necessary to provide an explanation in the development of TPS in this research study. This study included the foundational structure of the development, formalization, and implementation process used in TPS. Mercedes-Benz leaders modeled the MBPS after TPS, and both relate to the automotive manufacturing industry. TPS exhibits manufacturing lean principles and philosophies that guide and support the process when implementing quality production systems. Understanding of TPS is significant in explaining the acceptance of TPS being modeled in MBPS. The key components driving the association between MBPS and TPS was that

Mercedes-Benz cars accepted the success displayed by Toyota and they both include lean manufacturing approaches in automotive production systems (Gao & Low, 2014). Factors of success that are conducive to automotive engineering business practices are the fundamental drivers of TPS, and leaders of Mercedes-Benz cars implemented similar tools via MBPS. The fundamental drivers of TPS are standard operational procedures, sort, set to order, shine, sustainability, continuous improvement, and Kanban (James & Jones, 2014). The research summarized in Chapter 2 demonstrated the need for organizational leaders to implement quality production systems efficiently and robustly as indicated by MBPS implementation. Chapter 2 also included an explanation of the TPS as the best method for the automotive industry.

Background of the Study

The quantitative research literature relates to the scope of the topic by expressing the impact on Mercedes-Benz cars' productivity after implementation of the MBPS. In this study, I provided an empirical foundation for the TPS because it was the proven methodology for quality production systems in the automotive industry. An explanation of TPS was important because leaders of Mercedes-Benz cars modeled their quality production system approaches when creating the MBPS. The philosophy that guides the TPS was long-term thinking that evaluated risk factors such as short-term expenses, profits, and productivity. When not properly used, it leads to improper implementation of lean-manufacturing tools in quality production systems (Liker, 2004). Proper execution of lean methods led to the success of the TPS method in automobile manufacturing (Liker, 2004).

Many businesses have experienced mergers and other situations, such as the Mercedes-Benz Car Company. Based on evidence presented from previous contributors in the field like: Henry Ford, Joseph Juran, W. Edwards Deming, Sakichi Toyoda, Kiichiro Toyoda, Taiichi Ohno, and Eiji Toyoda. According to my research, MBPS functionality improved after implementing the TPS model as a fundamental quality production system; however, my research was not able to prove this success. Chapter 2 includes details of this research and expanded on specific aspects of the problem statement.

This research study discusses issues and challenges that have influenced the way the MBPS became relevant for the organization. Leaders developed and implemented new quality production systems, providing challenging project milestones for MBPS. The challenge of Mercedes-Benz cars was implementing the new quality production system, MBPS. Daimler-Benz and Chrysler created many disputes and limitations on the plan to establish methodical systems for MBPS. During the selection process with Daimler-Benz and Chrysler, questions arose within the team regarding the name of the new quality production system. The team, comprised of members from the Daimler-Benz and Chrysler sides of the business, disagreed on naming the new quality production system the Chrysler Operating System (COS) or MBPS. Prior to 1999, the board established the name DaimlerChrysler Operating Model (DCOM) to identify the production system (Clarke, 2005).

Uncertainty continued to plague the decision, with concerns regarding the brand, and immediately after confirmation of DCOM, the team voted MBPS as the new name of the production system. All Mercedes-Benz passenger car production plants worldwide used the production system name, MBPS. In 1999, DaimlerChrysler team approved the final agreement and acknowledged the new name of MBPS; implementation began in early 2000. The scheduled plan to evaluate, manage, and implement the change had a 2-year timetable between January 2000 and December 2002 (Clarke, 2005).

The gap in knowledge addressed in this quantitative comparative study was how cycle-time variation, employee-headcount variation, and KPIs affected productivity after implementation of the MBPS. The general gap in research pertained to improper implementation of quality production systems, such as the TPS in the automobile manufacturing industry (Miina, 2013). The aim of the proposed quantitative research study was to expose issues and challenges that influenced the relevance of the MBPS to the organization’s needs and how MBPS leaders developed the model, implemented it, and challenged project milestones. Change management was one of the largest challenges of implementing the MBPS: Mercedes-Benz cars attempted to implement the TPS model during the Daimler-Benz and Chrysler merger in 1999. This quantitative study was necessary to fill a research gap through a causal study to examine whether implementing MBPS was effective and successful. In this study, I examined how the independent variables (cycle-time variation, employee-headcount variation, and KPIs) influenced the dependent variable (productivity) between 1999 and 2017, after implementation of the MBPS.

Problem Statement

The successful implementation of quality production systems, such as MBPS, has been a general problem for automobile manufacturing companies around the world since the early 1900s (Gijo & Scaria, 2014; Miina, 2013; N. Kumar, Kumar, Haleem, & Gahlot, 2013). Names given to quality production systems include Lean Manufacturing, Six Sigma, Total Quality Management, and TPS. The aim of these quality production methods was to guide successful production-system implementations (Gijo & Scaria, 2014; Miina, 2013; N. Kumar et al., 2013). Improperly implemented quality production systems negatively affected the following performance indicators: production productivity, lean processes, cycle-time variation, throughput, change-over-time, downtime, wait time, rework, and cycle time (Bagozzi, 2012). Implementing lean tools was a good practice, but more than 90% of organizations around the world whose leaders attempted to implement lean production failed (Manoway, 2015). This high percentage of failure was due to a lack of competency in the lean concept and the incomplete implementation of quality production systems (Miina, 2013). Due to the high failure of companies implementing quality production systems, it was important for throughput, headcount, cycle time, productivity, and other traceable metrics to be properly implemented in the MBPS to avoid unfavorable or inconsistent productivity results (Alemi & Akram, 2013). Manufacturers need to focus on reducing cycle time to be successful (Kumar & Kumar, 2014). As product demand continues to increase, the need to focus on cycle time and productivity will also increase (Kumar & Kumar, 2014).

Current research articles supported the gap in this study on implementing MBPS; this research focussed directly on Mercedes-Benz cars' productivity after implementing the MBPS (Alemi & Akram, 2013). The successful implementation of production systems similar MBPS has been identified as a general problem for automobile manufacturing industry throughout the world as early as 1900s (Gijo & Scaria, 2014; Miina, 2013; N. Kumar, Kumar, Haleem, & Gahlot, 2013). The specific problem addressed in this study was how cycle-time variation, employee-headcount variation, and KPIs affected productivity after implementation of the MBPS. I investigated how Mercedes-Benz completed the effective implementation of the MBPS using the effect of the independent variables on the dependent variable to determine how productivity resulted. The quantitative research method included survey questions, which I distributed to a general population of employees of Mercedes-Benz. The goal was to collect survey responses from operation managers, plant managers, manufacturing engineers, and shop workers. This group was suitable because of its involvement in the daily activities related to productivity, cycle time, and employee headcount.

Purpose of the Study

This research study investigated Mercedes-Benz Car Company productivity after implementation of the MBPS in 1999. Its purpose was to investigate the effect of the independent variables —cycle-time variation, employee-headcount variation, and KPIs— on the dependent variable, productivity, by surveying, in a randomized distribution, employees of Mercedes-Benz cars (operation managers, plant managers, manufacturing engineers, and shop workers) employed between 1999 and 2017. The focus of this quantitative study was the impact on the dependent variable, productivity, within Mercedes-Benz cars after implementing the new MBPS quality system.

. This study included a cause-and-effect experimental method to form a foundation for the causal impact of the implementation of the MBPS. The study measured the impact of implementing the MBPS by observing the independent variables of cycle-time variation, employee-headcount variation, and KPIs between 1999 and 2017. The study compared 18 years of Mercedes-Benz Car Company productivity after implementation of the MBPS in 1999.

Research Questions and Hypotheses

1. How does the variation in cycle time (production time it takes for an operator to complete a job) affect the productivity of Mercedes-Benz cars?

$H1_0$: Variation in cycle time (production time it takes for an operator to complete a job) does not affect the productivity of the Mercedes-Benz Car Company.

$H1_a$: Variation in cycle time (production time it takes for an operator to complete a job) does affect the productivity of the Mercedes-Benz Car Company.

2. How does the variation in the number of employees (total number of employees in a production process) affect productivity in the MBPS between 1999 and 2017?

$H2_0$: Variation in the number of workers (total number of employees in a production process) does not affect the productivity of the MBPS between 1999 and 2017.

$H2_a$: Variation in the number of employees (total number of employees in a production process) does affect the productivity of the MBPS between 1999 and 2017.

3. What are the key performance indicators (KPIs) (data used to review productivity) in the MBPS that affected productivity between 1999 and 2017?

$H3_0$: KPIs (data used to review productivity) did not affect productivity in the MBPS between 1999 and 2017.

$H3_a$: KPIs (data used to review productivity) did affect the productivity of the MBPS between 1999 and 2017.

Theoretical Foundation

The focus of this quantitative research study was the MBPS and the foundation on which the MBPS rests—the original just-in-time (JIT) concept, lean manufacturing, TPS, six sigma, and total quality management. The research of seminal thinkers that support the MBPS were Henry Ford, Joseph Juran, W. Edwards Deming, Sakichi Toyoda, Kiichiro Toyoda, Taiichi Ohno, and Eiji Toyoda. The origin of the quality management strategy and planning aligns with a set of activities that guide organizational culture to eliminate waste and work toward achieving zero defects (Ciemnoczolowski & Bozer, 2013; Paraschivescu & Căprioară, 2014; Zaferullah & Kumar, 2013).

Major theoretical propositions and major hypotheses of Just-in-time (JIT), lean-manufacturing, TPS, six sigma, total quality management, and lean six sigma concepts entail helping an organization's operation achieve optimal productivity, eliminate waste, and continuously improve to drive return on investment (Lu, 1989). The implementation of quality production systems involves principles that employ human influenced technology that helps eliminate waste and reduces variability in the suppliers of internal and external processes within organizations (Mostafa, Dumrak, & Soltan, 2013; N. Kumar et al., 2013). Organizational leaders can implement lean principles throughout service and manufacturing industries (Mostafa et al., 2013). The effective implementation of quality production systems eliminates downtime, rework, wait time, and excessive quality inspections, which adds value (Miina, 2013). Chapter 2 includes explanations of quality production systems and TPS in more detail.

This quantitative research study included cycle-time variation as an independent variable. Godinho Filho and Uzsoy (2013) selected cycle time as the primary performance indicator while studying the importance of effective manufacturing processes. Cycle-time variation as a key indicator in research-based studies was an important component to the TPS (Godinho Filho & Uzsoy, 2013). The MBPS closely aligns to quality production systems and the TPS. As stated earlier, the origin of MBPS was supported by concepts of the original JIT concept, lean manufacturing, and TPS. My rationale for studying a lean concept was the need within the automotive industry to implement quality production systems and improve the causal impact that results. This quantitative, comparative study of the MBPS involved studying how the independent variables—cycle-time variation, employee-headcount variation, and KPIs—affected the dependent variable, productivity. Although many issues in the automotive industry relate to quality production system implementation, the topic was still important to impacting positive social change. The purpose for studying the MBPS was to identify whether the implementation affected the dependent variable, productivity. My quantitative comparative study advanced the topic of MBPS by investigating the proper implementation of lean quality production systems in building Mercedes-Benz cars. This study has implications for positive social change. By evaluating the effects on the dependent variable, productivity, after implementing the MBPS between 1999 and 2017, it could mitigate ergonomic risks; improve health and safety issues; and sustain productivity locally, nationally, and globally.

In this section, I align the theoretical framework to the research design and the gap in the research that was under investigation. The research questions were as follows:

1. How does the variation in cycle time (production time it takes for an operator to complete a job) affect the productivity of Mercedes-Benz cars?
2. How does the variation in the number of employees (total number of employees in a production process) affect productivity in the MBPS between 1999 and 2017?
3. What are the key performance indicators (KPIs) (data used to review productivity) in the MBPS that affected productivity between 1999 and 2017?

This quantitative, comparative research study involved examining the impact of productivity on the dependent variable. The independent variables cycle-time variation, employee-headcount variation, and KPIs was used as components of causal impact in this research study. This research effort involved investigating an 18-year period between

1999 and 2017 following implementation of the MBPS in 1999. The scope of this research study included evaluating the impact of cycle-time variation, employee-headcount variation, and KPIs on Mercedes-Benz Car Company's productivity. This study included survey questions distributed to a population of employees who worked for Mercedes-Benz cars using the MBPS. These individuals best represent the employees who worked directly with the company's manufacturing process. The survey participants—such as operation managers, plant managers, manufacturing engineers, and shop workers—met the criteria of having worked daily with activities related to productivity, cycle time, and employee headcount.

The study was a quantitative, comparative research study observing the cause and effect relationship on the dependent variable, productivity. The independent variables were cycle-time variation, employee-headcount variation, and KPIs after implementation of the MBPS [starting?] in the late 1990s. This research effort included a longitudinal review of data from employee responses between 1999 and 2017. The study involved evaluating the performance of Mercedes-Benz cars over [a period of?] 18 years after implementation of a new quality production system. This study involved analyzing the collected data with software in an analysis using nonparametric Spearman correlations at a 10% significance level and a 90% confidence interval using the software Statistical Package for Social Sciences (SPSS).

TPS theory relates to the study approach and research questions directly by measuring the impact of implementing the MBPS. This study investigated the dependent variable, productivity, by observing the independent variables cycle-time variation, employee-headcount variation, and KPIs between 1999 and 2017. This quantitative investigation represented the dependent variable, productivity while implementing quality production systems, streamlining, reducing process costs, and eliminating waste. This study also looked at how the covariate variable cycle-time variance affected the productivity of Mercedes-Benz cars. Research on Mercedes-Benz cars productivity was achieved by aligning the variable directly with comparative research between 1999 and 2017. This research also involved looking at another covariate variable, number of employees, and its impact on the productivity of Mercedes-Benz cars, which also aligned directly with comparative research between 1999 and 2017.

This quantitative comparative study included a survey questionnaire as the research instrument used to find KPIs (KPIs) in the MBPS that affected productivity between 1999 and 2017. I created a research instrument and distributed it, using SurveyMonkey to the general population of present employees who work for Mercedes-Benz cars. My focus with the data collection was gleaning information from operation managers, plant managers, manufacturing engineers, and shop workers—employees who were likely to provide the greatest value in survey responses based on their daily involvement in manufacturing activities and productivity related to cycle time and employee headcount.

Leaders at Mercedes-Benz created the MBPS by modeling the TPS, based on TPS’s proven success. Researchers have confirmed the significance of the MBPS in solving problems have positive impact on quality production systems in the automobile manufacturing industry. The empirical foundation established through the TPS lends strength to this study of the MBPS.

Nature of the Study

The rationale for selecting the design was to study and understand causality in this quantitative comparative study. I considered the phenomenon in terms of the influence of the independent variables cycle-time variation, employee-headcount variation, and KPIs on the dependent variable, productivity. I used $f(x)$ as the independent variables cycle-time variation, employee-headcount variation, and KPIs and y as the dependent variable, productivity, where y was a function of x or, mathematically, $y = f(x1, 2x, \ldots., xn)$. The methodology was a quantitative research study using data collected from employees of Mercedes-Benz cars between 1999 and 2017. I collected data by surveying a randomized sample of employees who worked directly for Mercedes-Benz cars.

This study included an analysis of covariance to consider differences in the variables of causality and to determine the performance score of the dependent variables. I selected this research method because when conducting a cause-and-effect study, it was difficult to establish causality with only limited degree of confidence. The goal of this study was to establish reverse causality because it was more acceptable. Reverse causality is a condition in research that exist when *X* variable and *Y* variable are linked; however, the connection is contrary to the concept of causality. When *Y* variable causes a change in *X* variable then the condition of reverse causality occurs. I used the mean of the dependent variable, productivity, by looking at the average performance of Mercedes-

Benz. I also used Spearman correlations instead of the more common Pearson correlations due to the sample size (*N* = 35).

Definitions

Definitions and terms frequently used in this quantitative comparative study that require further contextual explanation are as follows:

Chrysler operating system (COS): The name used for the MBPS after the merger between Daimler-Benz and Chrysler (Clarke, 2005).

Continuous Improvement Process (CIP): Tool in the Toyota Production System methodology used to eliminate waste in manufacturing processes (Dahlgaard, 2014).

Cycle time: The actual amount of time it takes to manufacture a part or to complete a process or series of processes from start to completion or staging location (Klarin et al., 2016).

Cycle-time variation: Changes made in manufacturing cycle time (Klarin et al., 2016).

DaimlerChrysler operating model (DCOM): The original released name for the production system presented by the board in 1999 (Clarke, 2005).

Employee headcount: The population, group, employees, or subjects selected to study (Baldos, & Hertel, 2014).

Employee-headcount variation: Changes in the population, group, employees, or subjects selected to study (Baldos & Hertel, 2014).

Ergonomic risk: Potential physical injuries caused from working in uncomfortable postures, high intense repetitive motions, or overexertion (Mostafa, Dumrak, & Soltan, 2013).

Kanban: An information system used to provide communication for every movement of each part throughout all processes in the production system (Ciemnoczolowski & Bozer, 2013).

Mercedes-Benz Production System (MBPS): The company-specific production system established for Mercedes-Benz Car Company by benchmarking and modeling the TPS (Lin, & Kang, 2012).

New United Motor Manufacturing, Inc. (NUMMI): Toyota was pivotal in actively establishing and partnering with companies that made up New United Motor Manufacturing, Inc. (NUMMI). These actions were key to the TPS becoming a globally recognized method (Cimini & Muhl, 1994).

Toyota Production System (TPS): The company-specific production system established and formalized by leaders of the Toyota Car Company (Nortje & Snaddon, 2013).

Assumptions

Assumptions are characteristics of a quantitative research studies that cannot demonstrate truth or validity; they are out of control because of human subjectivity while taking surveys. In this study, I assumed the holistic formalization of the TPS. Successes with the TPS model indicated the ability to develop successfully and validate the quality production system through proper implementation.

Researchers can assume, but not verify, a conclusion that was dependent on plausible cause-and-effect conditions (Jenson, Dominguez, Willaume, & Yalamas, 2013). Some researchers incorporate treatment variables, outcome variables, and posttreatment variables with causal-process assumptions to address casual effects (Glynn & Quinn, 2011). For this study, I assumed that the TPS was the manufacturing model chosen by Mercedes-Benz cars because managers believed the model would produce successes similar to those experienced by Toyota over the years (Iuga, & Kifor, 2013). The MBPS benchmarked Toyota's quality production system as a fundamental method, and for the proposed study, I assumed that leaders of Mercedes-Benz cars properly implemented the production system. These assumptions were necessary in the context of this study, because if leaders at Mercedes-Benz did not implement the MBPS at the same level of quality as the TPS, the results could differ.

Scope and Delimitations

The scope of this quantitative comparative study was to consider the effect of cycle-time variation, employee-headcount variation, and KPIs on productivity. The delimitations of the study included the research questions, variables, theoretical framework, methodology, and choice of participants. The inclusionary components of this study appear in the research questions:

1. How does the variation in cycle time (production time it takes for an operator to complete a job) affect the productivity of Mercedes-Benz cars?

2. How does the variation in the number of employees (total number of employees in a production process) affect productivity in the MBPS between 1999 and 2017?
3. What are the key performance indicators (KPIs) (data used to review productivity) in the MBPS that affected productivity between 1999 and 2017?

This research study sought to address the problem of how cycle-time variation, employee-headcount variation, and KPIs affected productivity from 1999 and 2017 after leaders at Mercedes-Benz cars implemented the MBPS. I distributed survey questions to a general population of Mercedes-Benz cars employees who worked for the company after implementation of MBPS in 1999. This group would best answer survey questions regarding Mercedes-Benz Company. Survey participants have had some involvement in daily activities related to productivity, cycle time, and employee headcount. I collected survey responses from operation managers, plant managers, manufacturing engineers, and shop workers. I analyzed the data using nonparametric Spearman correlations at the 10% significance level and 90% confidence interval in SPSS. This research design included three independent variables and one dependent variable. Automobile manufacturers around the world have problems properly implementing quality production systems such as six sigma, total quality management, TPS, and several other lean systems that were not part of this investigation.

Limitations

The research design was a limitation in this quantitative comparative study, as methodological weaknesses result from statistical analysis, operations research, and dependent and independent variables due to the quantitative characteristics of the models used (Choy, 2014; Lin & Kang, 2012). Models usually do not provide complete answers to research questions; however, the true nature of the results approximates the best answers possible (Choy, 2014). Biases that could have influenced this quantitative comparative research study though my personal experience as an engineer, working in the field, implementing the Lean six sigma and TPS tools. It was important that experts in a field do not induce bias in the research study with expertise and personal experiences in the field. The results of the study must be influenced solely by the research process and the data output from the study. I did not use my personal experience as an influence in the study and allow the research study to control the research. Possible bias could also have arisen in the analysis of quantitative data, particularly in estimating systematic errors that are present after implementing the research study design and analysis. I controlled the quantitative assessment of random error by using confidence intervals in estimates (Miina, 2013). Threats of validity from environmental factors associated with the field of study outside of the chosen independent variable that could lead to a plausible challenging hypothesis could also have limited the effect of this research study (Miina, 2013).

This study include the following types of validity: cross-sectional analysis, internal validity, external validity, and construct validity. Although validity relates to research, researchers should respond to different types of validity to ensure research rigor in a study. If a researcher properly addresses validity in a study, the researcher can achieve the goal of not facing generalization in the study. An in-depth explanation of validity, as it relates to this study, follows.

Based on the description of cross-sectional analysis, there may be one limitation of nonresponse bias. Like the leaders of many other companies, leaders at Mercedes-Benz chose to model TPS as the best production system predicated on a defined application of lean-manufacturing tools and methods motivated to guide organizations to optimal productivity. This selectivity could result in nonrepresentative responses. Limitations include threats to external validity. Given the typically misunderstood definitions of the differences between validity and validation, explanations by Cook and Campbell (1979), Guion (1976), and Cronbach (1971) defined it. Cook and Campbell explained validity as the estimate that best represents a fact or inaccuracy of an inference or prediction based on some level of research. Cronbach explained validation as encompassing a research methodology that researchers could use to examine the hypothesis of a research study. The premise of this research study was the effects of the independent variables of cycle-time variation, employee-headcount variation, and KPIs on the dependent variable, productivity, from 1999 to 2017, after implementation of the MBPS. However, this study surveyed employees from Mercedes-Benz after the implementation of MBPS. The employees who worked for Mercedes-Benz Car Company before 1999 were not a representative sample of the target population.

Based on the description of internal validity, this study faced another limitation. Cook and Campbell (1979) defined internal validity as a causality existing between the independent and the dependent variables relative to the operational definitions defined by the study. In this research effort, a threat to internal validity could exist based on the effect of the independent variables cycle-time variation, employee-headcount variation, and KPIs on the dependent variable, productivity. Therefore, the potential for internal validity could exist, and the outcome would result in an undefined research study, regardless of any relationships established between independent and dependent variables.

Based on the description of external validity, this research study could face another limitation. Data collection bias can identify threats to external validity. Selection bias could occur while executing data collection or while the sample was under investigation and thus may not represent the desired population. If selection bias was present during a study, the researcher would not be able to argue that the study outcomes were generalizable to a larger population (Bagozzi, Yi, & Phillips, 1991). This study has a reduced risk of threats to external validity by defining of the sample conditions for the selected population. The data were directly related to Mercedes-Benz associates after MBPS implementation in 1999.

Based on the description of construct validity, this research study could face another limitation. Frankfort-Nachmias and Nachmias (2008) defined construct validity in terms of testing conditions and the survey measurements compared to the theoretical background of the research study. The basis of this study was the general idea of TPS theory expressed specifically as MBPS modeled on the adoption of TPS principles. I grounded the study in many years of empirical data developed and formalized by researching automobile manufacturing methods.

This research included existing research instruments used in previously published research (Opara, 1995; Stout, 2014). Opara (1995) and Stout (2014) scientifically constructed the survey questions and established them with rigor. The survey questions may guarantee that psychometric requirements occur as proposed (Churchill, 1979). The basis of expectations was empirical informational research made available to confirm that the measurements were adequate; however, researchers suggested that more research was necessary (Opara, 1995; Stout, 2014).

Limitations in this quantitative comparative study were weaknesses that were out of my control and could affect the conclusions drawn from the study. Limitations included capturing accurate measurements of cycle time, productivity, and employee headcount. The limitation of this study was the decision to examine the variables cycle time, productivity, and employee headcount, which are limited the potential KPI’s chosen as effects in the study. The dependent variable, productivity, and the independent variables cycle-time variation, employee-headcount variation, and KPIs limited the study to a narrower focus. This research study on the MBPS was to fill the gap of available research on Mercedes-Benz implementing quality production systems, and access to limited amounts of research leave opportunities to fill research gaps. The lack of research and data on the MBPS has resulted in research gaps and opportunities to explore the effectiveness of implementation, current productivity, and topics that expand this subject matter (N. Kumar et al., 2013).

Significance

Significance to Practice

This study was expected to advance knowledge of MBPS. In this study, I elaborated on the idea of properly implementing quality production systems in automobile manufacturing companies by examining the MBPS. The study involved exploring results from survey data and included a review of annual reports between 1999 and 2017.

Significance to Theory

The theory used to support this study was TPS by researching the similarities with implementation of the MBPS and TPS. This research study expanded the body of knowledge on the analysis of productivity impacts to the MBPS after its implementation in 1999. Researchers chose not to investigate comparisons of the state of productivity prior to 1999. The goal of this study was to explore the impact of implementing the MBPS on productivity between 1999 and 2017. This study involved testing the MBPS to see how cycle-time variation, employee-headcount variation, and KPIs affect it. When quality production systems are effective, organizations benefit from improvements in performance indicators such as productivity, efficient processes, reduced cycle time, and increased throughput.

The general topic in this research was about implementing quality production systems efficiently based on the success of the TPS in automobile manufacturing. Closing this gap could improve manufacturers’ cycle time, employee variation, and productivity. The high level of improvement has been understood through the efforts of

Toyota successfully implementing the TPS. TPS was the industry's best method and has justified the response to implementing quality production in that industry. Impactful benefits ranged from levels within a company's productivity, employee headcount variability, production cycle times, and many other key performance metrics that are used to understand the health of companies. The framework of this quantitative research study was an investigation into the health of the Mercedes-Benz Car Company from 1999 and 2017. The goal of the study was to provide research results on the implementation of the MBPS with emphasis on productivity, cycle time variability, and employee headcount variability, and variation in KPI's.

Lean manufacturing tools and methods are contributing factors to employee headcount variation through hidden inefficiencies when measuring true wages in organizations. Manufacturing wages increased by 16% between 2000 and 2010, but this level of wage increase could be detrimental to an organization if leaders do not properly staff production systems. The financial impact of overstaffing the manufacturing production systems may terminate new production systems and lean methods. Langdon and Lehrman (2012) credited the increase in manufacturing employer expenses to employee benefit expenditures. If company leaders failed to implement lean-manufacturing tools and methods, it was common to increase employee headcount to meet customers' needs. [However?] Increasing employee headcount to compensate for not achieving customer demands was not a good practice. The journey to implement MBPS lean-manufacturing tools and methods began in 1999 and ended in the early 2000s. Implementation of lean-manufacturing tools and methods has real productivity impact when measurements based on the calculated results after execution. In 2011, Langdon and Lehrman (2012) and Hicks (2013) indicated that manufacturing compensation had a significant impact on the inflation of manufacturing costs. However, if organizational leaders properly execute manufacturing quality production systems, then lean tools and methods should reduce and regulate the cost benefit on companies' productivity, employee headcount variation, and cycle-time variation. In contrast, Langdon and Lehrman (2012) stated that statistics show support for inflated numbers in the areas of employee manufacturing costs presented in 2011. The statistical data measured as 15% of overall developmental cost and educational cost, which was presented as a premium increase constantly between 2000 and 2011 (Langdon & Lehrman, 2012). Hicks (2013) attributed the effects to global recessional changes, employee wage impacts, and higher unemployment rates.

After the implementation of the MBPS in the late 1990s, the Mercedes-Benz Car Company experienced a number of influences that challenged the success of implementing lean-manufacturing tools and methods. Based on the research results performance reflected outcomes of those of TPS. In addition, global regulatory changes and continuous wars zones in action presented trials during MBPS implementation. The implementation took place during changes to global economic stability, globally risky security conditions, technological advancements that risked the intellectual property of information in global communities, a workforce with higher skills that required increased wages, and imbalanced recession activity around 2008 (Hicks, 2013). Similarly, Toyota leaders faced negative impacts from a combination of events during the evolution of TPS, such as influence by the 1950 labor crisis, workforce fluctuations, unnecessary production overages, and large variations in employee headcount (Lai, Tsai, Wei, Li, & Lu, 2014). The risk of a financial decline led to negative responses to the unpreparedness of Toyota by driving bankruptcy possibilities and an unstable employee headcount. Global activity also challenged the realization of improved production-system implementation by Toyota to produce new products the TPS way (Lai et al., 2014). Toyota's management group coined a unique and focused method of performing product research, product development, and production systems implementation (Lai et al., 2014).

Organizational leaders around the world pursued and formalized the TPS method developed by Toyota leaders to be the ideal manufacturing production system in the manufacturing industry throughout the world (Lai et al., 2014). Even though the growth and formalization of TPS was successful and chosen as the best method in the manufacturing industry, Toyota still experienced business burdens similar to those present in the current global system. Business challenges such as government regulations, economic unrest, consumer market response, and difficult business conditions historically resurface. As expressed previously, the implementation of MBPS faced the effects of government policies globally, and the organization suffered negative impacts on growth and employee stability for automobile manufacturing wages and employee headcount, which disturbed productivity (Feldman & Pendland, 2003).

Researchers have investigated TPS through the eyes of leadership, operations management, lean, and Ford. Mercedes-Benz incorporated each evaluation of the TPS system into a discrete response from evaluators regarding the output of its success

(Feldman, & Pendland, 2003). Mercedes-Benz cars elected to model TPS in spite of contrasting views from some researcher's studies and articles (Feldman, & Pendland, 2003). Even though the delivery of TPS was a subject of concern, the confidence presented from the automotive industry made it the implementation model for quality production systems. The proper implementation of quality production systems was a factor in the topic of filling knowledge gaps in research and adding value in positive social change. The value in studying the MBPS was to identify whether the implementation was effective by investigating the impact on the dependent variable, productivity. Feldman and Pendland (2003) noted that Mercedes-Benz missed company-specific production methods through the framework of TPS methods. In contrast, researchers developed TPS using companies around the world, though led by Toyota leaders and Toyota's Japanese roots (Liker & Franz, 2012). Based on the empirical evidence of Toyota's success and the path of execution taken by the company leaders to formalize and develop TPS was an unprecedented contribution to the automotive industry. The automotive industry has acknowledged TPS as the best decision in implementing lean-manufacturing tools and methods successfully. Automotive manufacturing companies have experienced problems in successfully employing quality production methods. Improper execution of quality production systems has been the cause of problems for automobile manufacturing companies throughout the industry since the early 1900s (Miina, 2013).

Significance to Social Change

This proposed quantitative comparative study may advance the problem of properly implementing quality production systems in the automobile manufacturing industry. This study has positive social change implications. It could mitigate ergonomic risks; improve health and safety issues; and sustain productivity locally, nationally, and globally. The implications for positive social change include comparative benefits to automotive workers and end users. The audience for this research and those who could benefit are individuals who work directly in the automobile manufacturing industry, including engineers, manufacturing managers, shop floor workers, as well as consumers.

Summary and Transition

Since the early 1900s, leaders in the automotive-manufacturing industry have faced problems with successfully implementing quality production systems. Quality production systems are key factors in the success or failure of an automotive company, if not implemented properly. The performance indicators affect automotive companies when issues arise in implementing quality production systems. For example, the following indicators are directly related; production productivity, lean processes, cycle-time variation, throughput, change-over-time, downtime, wait time, rework, and cycle time. As product demands decrease or increase, automotive organizations must focus on lean quality implementation.

My intention in this study was to fill a gap in the body of knowledge regarding the implementation of quality production systems. The gap that was filled directly was an investigation of productivity in the MBPS between 1999 and 2017. The progressive path of implementing MBPS in the Mercedes-Benz Car Company underwent many trials prior to formalization and the implementation phases. Leaders in the Mercedes-Benz organization experienced pressures as unstable influences, such as a merger, obstructed the original production system path. Leaders at Mercedes-Benz cars chose TPS as the best method and carefully pursued this rigorous option based on the success Toyota's management team experienced during its tenure in the automotive industry. Leaders at Mercedes-Benz cars researched the following areas as potential areas to improve its quality production system in the following domains: product research and development, new product market introductions, and shop-floor production system implementation (Lai et al., 2014). The areas discussed are the areas where Toyota's success was developed and showcased while thriving through continuous improvement**.**

Chapter 1 included a foundation for exploring the influence of the independent variables cycle-time variation, employee-headcount variation, and KPIs on the dependent variable, productivity. This research included survey questions randomly distributed to a sample of a general population of Mercedes-Benz employees. This study focused on dates from 1999 to 2017, after the initial implementation of the MBPS, which leaders modeled after the TPS. Chapter 2 includes details of this quantitative comparative research and expands the problem statement.

Chapter 2: Literature Review

Introduction

A synopsis of the current literature established the relevancy of the problem: improper execution of quality lean tools, which resulted in an unfavorable outcome of more than a 90% failure in the automotive manufacturing industry (Miina, 2013). Unsuccessful implementation of quality production systems in automotive manufacturing has been a general problem for many organizations globally (Miina, 2013).

Quality production systems are quality systems identified as lean, six sigma, total quality management, TPS, among others, which, when properly implemented, guide quality production systems toward success. Improperly implemented quality production systems negatively affect several performance indicators in automotive manufacturing organizations, including production productivity, lean processes, cycle-time variation, throughput, change-over-time, downtime, wait time, rework, and cycle time, as well as other complex issues that interfere with a system's success. The proper implementation of lean tools is an effective practice; but unfavorable outcomes occurred in more than 90% of automotive manufacturing organizations globally whose leaders attempted lean-production implementations. This high percentage of failure was due to a lack of competent experts in the process of developing lean concepts and incomplete implementation of quality production systems (N. Kumar et al., 2013; Miina, 2013).

The purpose of this quantitative, comparative study was to examine the effects of cycle-time variation, employee-headcount variation, and KPIs on productivity between 1999 and 2017. The specific problem was how cycle-time variation, employee-headcount variation, and KPIs affected productivity after implementing the MBPS. The purpose of this study was to explore how the independent variables cycle-time variation, employee-headcount variation, and KPIs affect the dependent variable, productivity. I achieved research validity by performing an empirical review of the history of the TPS, MBPS, cycle time, and productivity.

Literature Search Strategy

The following electronic databases were used to identify relevant literature: Google Scholar, EBSCOhost, and Google. The website ?? of the Institute of Electrical and Electronics Engineers was also helpful. The key search terms were as follows: *MBPS, TPS, productivity, continuous improvement, JIT, cause-and-effect research, cycle time,* and *components of quantitative research*. The following types of literature were reviewed from the early 1900s to 2016: peer-reviewed journals, dissertations, and books. Approximately x documents were reviewed of which x were included in this literature review. The years searched ranged, which shows that quality production systems are still necessary and relevant to current advanced manufacturing.

The literature review established validity through the best methods practices presented from studying the TPS, which served a platform through which leaders at the Mercedes-Benz Car Company effectively modeled this quality production system. This research study also included empirical groundwork in the development of the MBPS. The history of success attained at the Mercedes-Benz Car Company motivated Lu (1989) to express the probability of continuing success as the organization employs the MBPS. The

MBPS improved the Mercedes-Benz cars production-system infrastructure, the quality output, and the cost of the cars produced.

Mercedes-Benz leaders modeled the MBPS after the TPS based on the historical results of the TPS. Because Toyota's method was the best in the industry, this quantitative comparative study included an overview of the TPS. The TPS served as a template for establishing the MBPS.

Theoretical Foundation

In Chapter 1, I briefly introduced theories closely related to the study. In Chapter 2, I include an explanation of how I built the study. This quantitative comparative research study involved examining the theory behind the MBPS. Seminal thinkers who represents the original source of lean manufacturing methodologies used in MBPS are Sakichi Toyoda, Kiichiro Toyoda, Taiichi Ohno, and Eiji Toyoda (Ciemnoczolowski & Bozer, 2013). These seminal thinkers have been active in contributing to the development and formalization of lean manufacturing best practices globally in manufacturing production systems. This research study expresses a history of implementation of best methods with quality production systems in automotive industry. Furthermore, the background of TPS methods are principal viewpoints that influences progression of these scientific manufacturing tools by using business case investigations that incorporates efficiency, productivity, and waste type deliverables to define efforts (Ludwig, 2014; Martínez-Juradoa, Moyano-Fuentesa, & Jerez-Gómez, 2014).

Mostafa et al. (2013) defined lean manufacturing as a system with respected management practices that involves applying the best methods to eliminate waste and reduce supplier, customer, and process variability. This definition of lean served as a framework to explores the literature and provide a research-based analysis of how researchers have applied this theory in similar ways to this research study (Ciemnoczolowski & Bozer, 2013; Mostafa et al., 2013). Although concepts such as six sigma, total quality management, throughput, change-over-time, downtime, wait time, and rework are delineations of assumptions appropriate to the application of theory in this quantitative comparative study, I did not include them in the scope of this research study.

The best method of quality production systems for the automotive industry was the framework developed through TPS-based perspectives that primarily involve embedding scientific management tools such as time and motion studies, continuous improvement of processes, and a compensation system (Martínez-Juradoa et al., 2014). Leaders at Mercedes-Benz modeled the MBPS method on the TPS proven methodologies that made them successful. TPS was based on proven achievements, ability to develop successful auto manufacturing practices, and Toyota’s ability to formalize and implement a successful quality production system. The MBPS includes Toyota’s quality production system as a fundamental best method.

Sustaining the positive effects of success from process improvement implementation over time was a challenge (Netland 2013; Ţenescu & Teodorescu, 2014). Therefore, the success of the TPS has inspired leaders of companies who model this method as the best production system to strengthen and improve competitiveness. Since the mid-1900s, leaders of companies in the automotive industry have created systematic improvement programs influenced by the TPS, including the MBPS, the Volkswagen

Production System, the Ford Production System, the Opel Production System, the Audi Production System, and the Hyundai Production System (Faccio, 2014; Netland, 2013).

Literature Review

History of Toyota and Mercedes-Benz Production Systems

The research study constructs of interest are productivity, cycle time, and employee headcount. The methodology chosen for this research was a quantitative comparative study to evaluate the effect of cycle-time variation, employee-headcount variation, and KPIs on the dependent variable, productivity. Research on the history of production systems revealed ways researchers have approached the problem of improperly implementing quality production systems in the automotive industry. This research also includes a discussion on the formalization, strengths, and weaknesses inherent in approaches to the discipline.

Joseph Juran contributed to managerial processes, and the quality trilogy consists of quality planning, quality control, and quality improvement (Paraschivescu & Căprioară, 2014). Collectively, Deming and Juran recognized the need for quality improvement systems and advocated for them by developing the cost of poor-quality method (Paraschivescu & Căprioară, 2014). Sakichi Toyoda and Kiichiro Toyoda coined the term *lean* in manufacturing, also known as the TPS, and Kiichiro Toyoda was responsible for the term JIT (Faccio, 2014; Marodin & Saurin, 2013). Eiji Toyoda made a significant addition to the TPS by adding the philosophy of kaizen, also known as continuous improvement (Godinho Filho & Uzsoy, 2014). Ohno actively contributed to the TPS by adding the Kanban system, Kanban provides product information communicated using a tagging system (Zaferullah & Kumar, 2013) and expanded on the JIT concept (Marodin & Saurin, 2013; Zaferullah & Kumar, 2013). Ford was a major contributor to the evolution of advanced automotive quality production systems with the development of the automotive assembly line (Marodin & Saurin, 2013; Zarbo, Varney, Copeland, D'Angelo, & Sharma, 2015). Many contributors to the field have improved production systems throughout the global community (Kim, 2013; Wang et al., 2014).

To understand TPS as the best method in the automotive manufacturing industry, a deeper understanding of its history is necessary. This chapter includes an historical explanation of TPS. The evolution of quality production systems has included many approaches involving such methods as Taylorism and standardization, Ford's mass-production system, and other production-management thought patterns (Vidal, 2015, Yamada, 2014). The variables productivity, cycle time, and employee head count are key parameters in measuring performance (Kumar & Kumar, 2014). The basic principles that shape the purpose of quality production systems are to properly implement quality production systems, eliminate waste, and achieve the concept of zero defects (Paraschivescu & Căprioară, 2014).

In the early 1920s, the market in Japan mirrored the market in Germany, and the response to production systems meeting market demands was limited to a small population of wealthy members of the upper class (Iuga & Kifor, 2013). Automotive production referred to a much smaller business plan, with companies expecting to produce a cumulative throughput of a few hundred units. In 1925, production of Japanese automobiles gained momentum when Ford developed the first knock-down assembly

U.S. subsidiary in Yokahama, Japan, and introduced the moving assembly line for chassis and body-assembly lines. General Motors (GM) leaders modeled Ford Motor Company and developed a knock-down assembly U.S. subsidiary in Osaka in 1927 (Wilson, 2014). Smaller U.S. automakers such as Chrysler decided to make smaller foreign investments in Japan by opting to import their parts to Japan and contracting with Japanese companies to assemble the units (Vidal, 2015).

Although U.S. automakers dominated the automotive market in Japan in the 1930s, Kiichiro Toyoda developed the automotive branch of Toyoda Automatic Looms Work Ltd., known as Toyota Motor Co. Ltd. and directed the organization to focus on the research and development of automotive engines (Rutledge, & Martin, 2016). In 1934, leaders of Toyota Motor Co. Ltd. started building pilot plants, helped introduce machine tooling from Germany and the United States, and completed the first prototype engine. In this research-and-development phase, Toyota also disassembled Chrysler and Chevrolet cars and copied parts of Ford and other U.S. automobile manufacturers. Research and development completed during this time led leaders at Toyota to implement the building of car bodies, chassis, and gear parts. After developing enough parts to produce the first Toyota prototype automobile, Kiichiro Toyoda encouraged a team to visit U.S. automotive manufacturers and develop knowledge of mass production. Toyota used the knowledge gained on mass production to build the first Toyota prototype, the A1 model, which was a five-passenger sedan using a 3400c engine. The A1 model was a direct imitation and patchwork of automotive technology developed by U.S. automotive companies. Though Toyota used US companies' passenger car designs, development of

Toyota's A1 model only impacted U.S. automakers by about three percent the market share. After learning about sector regulations introduced by the government, Toyota leaders switched their research-and-development focus to producing trucks (Wilson, 2014).

In the same year the A1 model was launched, the total performance of assembly output in all U.S.-based automotive knock-down plants reached 92% of market share in Japan (Wilson, 2014). As leaders at Ford observed Ford's performance record against the actions of other automobile companies, they committed to a new, much larger plant as part of their continuing strategy to enlarge global operations. During this time, Ford production system was established, and Japanese manufacturers exposed Ford's pursuit of automotive manufacturing growth. Ford's expanded growth even generated new operations in the United Kingdom (Wilson, 2014, Yamada, 2014). However, U.S. automakers' dominance in Japan was short lived, as the Japanese government continued efforts to develop sufficient supplies for military vehicles.

The Japanese government introduced the Automobile Manufacturing Enterprise Law in 1936, which dismantled the automotive efforts of domestic and foreign automakers in Japan. The law affected Japanese domestic organizations in two major ways. First, by the end of the 1930s, the Japanese legislation forced the shutdown of U.S. automotive plants in Japan because it prevented operations of foreign automakers in Japan. Second, the law subsidized three Japanese domestic truck manufacturers in an effort to fill the gaps left by the departing U.S. manufacturers (Chiarini, & Vagnoni, 2015). Responding to the exits of U.S. companies in Japan, in 1933, Nissan Motor Co.

Ltd. was founded; in 1937, Toyota Motor Co. Ltd. was founded; and in 1949, Isuzu Motors Ltd. was founded; originally named Tokyo Jodosha Kyosho. The Toyota plant in Kariya, Japan produced 150 units per month compared to the Ford plant, which produced a few thousand units per month. To meet Japanese domestic demands for automobiles, Kiichiro Toyoda built the largest plant of the time. The Toyota plant at Koromo opeend in 1938, had 5,000 employees, and produced about 200 units per month (Clarke, 2005).

As Toyota continued to develop and grow, production concepts developed by Ford knock-down plants had a large influence (Vidal, 2015). Company leaders also attempted to understand the economic benefits of strategies such as product standardization, interchangeable parts, special-purpose machines, and the moving assembly line. Although Toyota Car Company could not duplicate the U.S. mass-production system, they adopted different parts of the system by leveraging certain limits of the domestic market and the current production system. In contrast, Nissan's dependences relied on product development research and process method implementations produced by Toyota and Ford to build technology in its production system.

Cusumano (as cited in Clarke, 2005) suggested capitalizing on existing knowledge with local workers and developing a production system suitable for the current Japanese climate and economic conditions. However, production operations at Toyota still involved craft-type production methods. In earlier TPS influences by Fordism and Taylorism, craft-type jobs had workers holistically involved in performing expert skilled task, such as machine tool operations on a large number of the parts for production and performing machine setup operations such as sharpening cutting tools and preventive maintenance on machines. In contrast, the future changes in the TPS removed specialized expert skills from craft-type work and let engineering development cycle of design and higher level skilled be performed by experts. Craft-type production was disruptive and inefficient in a manufacturing process flow, work-in-progress (WIP) inventories stack-ups, and machine-use balance. Fujimoto (as cited in Clarke, 2005) recommended the company continue to produce using craft-type production methods into the 1940s. Even though Ford displayed a strong influence and Taylorism was one of the preferred production methods during this time, Toyota leaders chose to operate contrary to the status quo (Concas, Lunesu, Marchesi, & Zhang, 2013). Toyota leaders introduced the early TPS using craft-type production methods.

The next challenge for Toyota came after World War II when the organization faced financial-resource limitations and operated with a diminished technological research-and-development budget to help improve production capabilities (Kim, 2013). Toyota leaders worked to improve productivity by maximizing current resources, which involved coupling elements of Taylorism's standardization of work design with other company-specific elements: production flow, machine layouts, multitasking (takotei-mochi), and leveling production pace (heijunka) and, based on responses from Fujimoto, implementing these tools significantly reduced the influence of craft-type production. Benefits accrued in a few ways. Although craft-type manufacturing methods became chaotic and created conflict between craft workers and foremen working on the shop floor, the new measures caused production performance to increase significantly.

However, organization leaders were not ready for this level of productivity and experienced overproduction during a recession, which led to a potential bankruptcy at Toyota and caused a major reduction in the workforce (Iuga, & Kifor, 2013). The combination of workforce reductions, overproduction, and massive numbers of long-term workers being out of the workforce led to the labor crisis of 1950 (Lai et al., 2014).

Changes in the financial state of Toyota transformed from the 1950 labor crisis when leaders of the American Army Procurement Agency issued a significant number of orders for motor vehicles during the Korean War (Chiarini, & Vagnoni, 2015). The Japanese motor industry benefited greatly from the orders. The Toyota managing staff responded to the recovery by developing and launching several new truck models and launched the Crown RS-30 sedan in 1955. As the business structure and market climate changed, Toyota leaders decided not to produce any vehicles under license agreements with European automobile manufacturers (Iuga, & Kifor, 2013). Leaders at Nissan and Isuzu chose to produce new products in this way (Lai et al., 2014). Toyota's management team focused on establishing its identity in research, development, and production methods (Rutledge & Martin, 2016).

Toyota continued to progress in a parallel path and focused on the development of passenger cars and the implementation of U.S. management methodologies based on scientific-management principles (Lai et al., 2014). During the 1950s, Deming lectured on issues of quality control and efficient manufacturing processes in Japan (Lai et al., 2014). Toyota learned and implemented quality-control tools. Using statistical quality controls such as Shewhart control charts, Toyota leaders were able to share information throughout the organization (Ham & Park, 2014). First-line supervisors learned to use statistical quality control tools to communicate information on the shop floor geared toward continuous process improvement (Ham & Park, 2014; J. Li, 2013).

Toyota also built an infrastructure of its own solution-driven production methodologies with a primary focus on embedding scientific-management tools such as time and motion studies, continuous improvement of processes, and a compensation system (Pakdil & Leonard, 2014). The implementation of these foundational structures resulted in a proportional increase in performance incentives and improvement in process efficiency (Ludwig, 2014; Spatz et al., 2015). A positive linear relationship emerged between key successes, continuous-improvement processes (CIPs), and compensation systems (Parkes, 2015; Sanchez & Blanco, 2014). By the late 1950s, Toyota leaders had implemented several manufacturing technologies: the Kanban system, a production-control system, and an inventory-control system (Faccio, Gamberi, & Persona, 2013).

The methods and lessons learned through the earlier research-and-development life-cycle positioned Toyota for the 1960s-massive demand for customer automobiles in the domestic market (Rutledge, & Martin, 2016), which necessitated building large-scale manufacturing facilities that would be a pathway to meeting the demand for the automobile growth rate of 26.9%. Product demand was so fast between 1960 and 1970 that Toyota's production output increased from 500,000 to 5 million units per year. The unexpected market demand for passenger automobiles caused a shortening of product-development life cycles; as a result, development timelines for producing a new product decreased to 4 years (Clarke, 2005). The market demands forced the development of systems integration with suppliers (Choy, Mokuau, Braun, & Browne, 2008). Toyota leaders implemented the black-box-parts method during this period to help speed up the developing process (Faccio et al., 2013).

The supplier integration system further evolved to advance the product-development process by dividing automotive-supplier segments by research-and-development expertise and design-and-construction capabilities (Ringena, Aschehouga, Holtskogb, & Ingvaldsena, 2014). This category of suppliers became Type I suppliers, tasked with providing production parts. In line with developing the supplier-integration system, Toyota leaders also developed and implemented a company-wide total quality management system. As the new company-wide production system materialized, Toyota invited suppliers in the supply chain to study the new production methods. Supplier invitations helped accomplish two things: (a) the approach allowed the Toyota managing staff to demonstrate its efficient production process in real time and (b) this approach helped educate suppliers about the actual production system on the shop floor (Ringena et al., 2014).

The breadth of Toyota's development in the 1960s resulted from a major market shift in Japanese domestic demand. International growth in demand in the 1970s led to intense export efforts (Rutledge, & Martin, 2016) that continued to increase through the 1980s. Japanese manufacturers increased export sales, largely led by the North American market increasing from 1 million to 6 million. During this time, Toyota leaders faced global and internal issues such as an oil crisis, environmental mandates for lower emissions levels, and massive expansion of a global customer base (Iuga, & Kifor, 2013).

The success of the TPS resulted from three measures that improved supplier relationships, internal production management, and supplier management of manufacturing performance (Kim, 2013). First, Toyota leaders made investments in developing engine technology. Second, Toyota leaders created a range of models tailored to customer demands outside of Japan (Rutledge, & Martin, 2016). Third, Toyota leaders sharpened reformation of the production system to focus primarily on continuous improvement in productivity and quality (Rutledge, & Martin, 2016). Improvements also included manufacturing-performance matrices centered on quality, cost, and delivery (Kim, 2013).

The premise of Toyota's strategy was to develop a systematic approach in the production system by creating a transfer of standards driven to develop close links between assemblers and the suppliers using a method that included Kanban delivery and eliminating receiving inspections on incoming parts (Ullah, 2014). Toyota leaders routinized manufacturing and learning capability by synchronizing the relationships and interfaces between manufacturers and suppliers. Other Japanese manufacturers recognized the success of the TPS methods (Iuga, & Kifor, 2013).

The work completed in training suppliers on Toyota production principles progressed ahead of the formalization of the TPS. Toyota's executive president Taiichi Ohno attempted the first formalization effort in 1978 by publishing a description of the TPS. The TPS became the model production method for companies in Japan. Leaders of Japanese organizations began to use these production-system methods as best in the industry. During the mid-1970s to 1980s, the leaders of Japanese companies increased export rates and manufacturing efficiency and earned global recognition for their performance. Attention on Toyota's performance from the international community became a major political topic in the United States after the big-three U.S. automakers experienced a heavy reduction in sales. Pressure from the U.S. government and United Auto Workers union drove the Japanese government to adopt a voluntary restraint agreement that limited the import of Japanese cars through a quota. Toyota responded to the regulatory pressures by creating plants in North America and Europe and influenced more than 200 Japanese automotive suppliers to duplicate these efforts (Chowdhury, 2014).

Efforts by the Toyota managing team made decisions that allowed TPS methods implemented to impact productivity in three different successful paths and advance the production system: the TPS was developed further through the transplants and joint ventures outside Japan; Toyota leaders developed new Toyota plants in Japan in the 1990s; and Toyota leaders developed new plants as joint ventures that were more specific even than worldwide GM plants. Setting up transplants outside Japan played a major role in developing the TPS that formalized the TPS by introducing and exposing the TPS to Western joint-venture partners. Even though the TPS emerged in the 1970s, Toyota managers reintroduced the concepts and methods of the TPS in English, which set the foundation and allowed Toyota leaders to clarify the logic that influenced the methods in the production system (Chowdhury, 2014).

One major challenge of the global expansion effort into North America was the balance of production-system compatibility, which caused a major development interface between the TPS and the production systems developed throughout the Western world. Toyota leaders introduced the concept of application adaptation, which served as a way to introduce superior Toyota management and production systems. Application adaptation allowed maximum application transfer and possible modifications to the system as Toyota production adapted to local environmental situations (Chowdhury, 2014).

Toyota Production System: New United Motor Manufacturing

The establishment of the NUMMI between GM and Toyota Motor Company occurred in the 1980s (Chowdhury, 2014). This relationship helped Toyota learn more about the U.S. suppliers and labor force. In return, the GM team wanted to learn about Japanese methods of manufacturing. The NUMMI leaders made minimal changes to the TPS originally but developed a comprehensive strategy to implement a clean-sheet transfer of the production system consisting of the core objective of the TPS, including TPS standardization, the standardized operating sheet, the initial TPS approach, tasks that workers performed, analysis performed on basic motions, and sequence of work motions. After capturing details of the TPS standardized operating details, the NUMMI leaders refined and optimized the system to achieve maximum performance (Chowdhury, 2014). Team leaders and workers were responsible for continuous improvement (Godinho Filho & Uzsoy, 2013, 2014).

Efforts made in the TPS manufacturing methods and training presented made adaptation easier (Godinho, & Uzsoy, 2013, 2014). However, local conditions required the Toyota management team to perform an adaptation of the TPS to U.S. regulating standards that aligned with labor concerns. Labor union leaders agreed to work with

Toyota and give up rights to strike on the subject of work standards, health issues, and safety issues. The NUMMI contractual agreement included the responsibility to report to the union on issues ranging from work pace to major investments. The benefit to the NUMMI was an opportunity for Toyota leaders to manage the transplants and gain access to managing the system. Toyota's leaders managed the transplants through the bulk of TPS principles, such as administrative structure and supplier relations to the NUMMI. The NUMMI leaders were able to adapt to the U.S. workforce, labor union, government regulations, and overall culture. However, the NUMMI leaders failed to develop and implement a new global standard for manufacturing performance (Chowdhury, 2014).

Leaders of Japanese companies continued to build a body of work that provided a benchmark and global leadership in the elements of technical expertise. Setting up the transplants was successful in highlighting the foundational structure for productivity and quality functions that originated from the Japanese. TPS was formalized and accepted in the manufacturing industries as the best method for quality production system implementation. The confidence and positive energy gained during the formalization process of the TPS was proven scholarly and a respected component of lean methodologies used in global manufacturing.

Toyota Production System (1992)

The traction gained in the formalization process of the TPS included turning the TPS into a scholarly topic in the manufacturing world, distinguishing between Eastern and Western manufacturing methodologies, and becoming a global conversation in its market. Researchers identified differences between Eastern and Western manufacturing practices and attempted to show that Japanese methods held a competitive advantage. The influence of TPS increased in the early 1900s when five authors from the Massachusetts Institute of Technology (MIT) completed a research study on quality production systems. Western automotive manufacturing companies were hesitant to embrace lean thinking methods through TPS in manufacturing plant at the initial release of the MIT publication but shifted interest soon after (Chiarini, & Vagnoni, 2015). The TPS emerged as a method capable of producing quality automobiles using less labor. During the early 1900's, MIT authors also developed the *International Motor Vehicle Report,* which increased awareness and brought pressure to Westernized automotive organizations (Rutledge, & Martin, 2016). The TPS's results increased its recognition, and support from scholarly research applied greater pressure to leaders of automotive companies using Westernized quality production systems and methods (Gao & Low, 2014). The MIT authors voiced support and validated the TPS to be the universal best method in the automotive industry for production performance and corporate organization (Gao & Low, 2014).

Pressure from the TPS methods caused leaders of Western automobile manufacturers to face cuts in the market share of automobiles sold in the United States (Chowdhury, 2014). In response, leaders of Western automotive companies collectively joined the conversation with the Western academics, consultants, and authors to understand and improve production-system methods. Western automotive companies used a phased approach called learning from Japan (Clarke, 2005).

The TPS experienced many challenges in the efforts to gain recognition as a credible production system in the global automotive community. Introducing the TPS methods to the Western automotive industry was slower to adapt based on the cultural, historical, and social background of Japan. In spite of Japanese cultural challenges, the TPS gained credible progress through the MIT study (Clarke, 2005), which led to introducing the TPS to the global community as the paradigm in the lean production system conversation (Weaver et al., 2013).

Influenced through changing economic effects that loomed from the coming recession and changes to Toyota's aging workforce, the next phase of change in TPS surfaced for Toyota. Repercussions of the aging workforce caused issues for Toyota because it reduced the potential for sustainability of work experience and difficulty recruiting skilled worker. Baby boomers at Toyota were maturing, which affected the organization's expense balance due to a larger number of employees being on the higher side of pay scales and benefits (Clarke, 2005). Two developments occurred after the lean period of the evolution of Toyota's mobility into mainstream global influence for quality production systems (Weaver et al., 2013): organizational changes and changes to the framework of the TPS. Toyota leaders revisited the adaptation principles that Toyota experienced earlier in its development. First, Toyota reduced the levels in its hierarchy and career path by completing a reorganization effort with white-collar workers in administrative and technical expert areas (Rutledge, & Martin, 2016). Toyota leaders decided, during the reorganization, not to affect the hierarchy of blue-collar workers on the production side of the business as a way to maintain stability and expertise in production controls. Second, Toyota leaders readdressed the remuneration system by developing an age and skills bonus and reducing the productivity bonus to 40% from 60%. Reorganizing the remuneration system changed the structure of the assessment of staff potential. This change influenced the staffing potential and markedly affected pay-level differentiation (Clarke, 2005).

Toyota leaders faced the challenges of the recession in late 1980s and established efforts based on financial conditions. During the economic challenges, Toyota leaders evolved the TPS from a lean production system to a super-lean production system. Toyota leaders introduced the concept of worker morale and improving productivity simultaneously into the TPS framework by changing production layouts focused directly on the structure of the assembly line (Jayamaha, Wagner, Grigg, Campbell-Allen, & Harvie, 2014) using the concept of CIP. Toyota designed CIP to improve the assembly line continually by responding to all changes in the process, which include social, environmental, and developmental maturing of skill level and attitude in adapting to kaizen (Jayamaha et al., 2014).

Three adaptations are noteworthy. The links between independent production lines are dependent on wasted buffer space that replaced wasted space with about four to five vehicles, which increased WIP unnecessarily (Concas et al., 2013). Traditional lean production principles considered this case to be of no value and claimed it would work against the efforts presented by the TPS concept of CIP (Khan et al., 2013). In contrast to beliefs of traditional lean production principles, key issues identified in are cases of process waste, non-value-added process inefficiencies, and negative impact on productivity in production lines (Khan et al., 2013). The second link was the coined term, 3K image, which represents three words: dirty (*kitanai*), stressful (*kitsui*), and dangerous (*kiken*; Clarke, 2005). These words described the expectation of an automotive facility or work atmosphere of that period. However, unavailable or fluctuating male labor resources affected this period even more. The third link was the design of production layouts (Khan et al., 2013). During this period, most Toyota facilities had one long production line (Amasaka, 2014). The basis of the Kyushu assembly line layout design was the concept of a fishbone structure with one central spine depicted as the main assembly line and lateral bones extending to feeders or mini assembly lines (Amasaka, 2014). This format massively enhanced efficiency.

In comparison to the original manufacturing methods of the TPS, the buffer method affected the work produced in three ways. Psychological risk aligns with operators using emergency pull cords to stop the mini-line while the main assembly continues to operate. This human interface with the product decreased the pressure affecting the main assembly line and, in some cases, removed pressure from operators completely. Also, the mini-lines delivered complete tasks, parts, or processes. Work and job rotations became increasingly independent. Plant teams organized and maintained the mini-lines constructed with leadership teams that had complete responsibility for managing and controlling the team, as needed, in a local fashion (Clarke, 2005).

The TPS evolved primarily because Toyota adopted and partnered with the methodology in the West, mainly through GM international plants. After gaining credible knowledge of the Japanese methods of manufacturing through the TPS, GM leaders took a major step to model the TPS independently without partnering with Toyota. In the early 1990s, GM leaders allocated a core group of employees to study and work in the TPS to implement the system into a new Opel Eisenach Production System. Twenty advisors worked to transfer the TPS to the West with the capability of producing a true lean system. During the TPS transfer of knowledge, Opel Eisenach Production System team members built a plant-system concept primarily dedicated to manufacturing small cars (Clarke, 2005). The system contained a specific manufacturing process layout and had little potential for vertical integration (Choy, Mokuau, Braun, & Browne, 2008; Ciemnoczolowski & Bozer, 2013). Nonetheless, the primary focus of TPS was lean manufacturing that produces the highest efficiency and a focus on standardization in all processes throughout the organization (Ciemnoczolowski & Bozer, 2013). For example, the TPS required employees to be skilled and intimate contributors to the system by performing time studies, writing and revising standard operating sheets, and constantly pursuing continuous-improvement initiatives (Ali & Deif, 2014; Ciemnoczolowski & Bozer, 2013). In the TPS, the main assembly line controls the production flow to drive takt time and work rhythm; teamwork controls the work organization expected as part of the work culture (Ali & Deif, 2014; Xanthopoulos & Koulouriotis, 2014). Toyota performs TPS work foundationally based on regulated highly standardized work instructions that define the content of each task and the training needed to perform it (Ali & Deif, 2014).

Leaders at Mercedes-Benz modeled the MBPS on the fundamental structure of the TPS (Morgan & Gagnon, 2013) to yield a company-specific production system that defined and provided a formal approach to achieving lean manufacturing (Vujica Herzog & Tonchia, 2014). The TPS management team takes the structured unified-production system and applies methods of continuous improvement (Ham & Park, 2014). In contrast to some predecessor production systems, the TPS management team contests scientific paradigms by building a foundation of firm-specific patterns with structured routine capabilities (Schonberger, 2014).

The TPS methodology includes a cumulative and evolutionary process of development and sustainability over time that has allowed Toyota to build, test, and improve automobiles (J. Li, 2013). Toyota's quality production system TPS has overcome issues in automobile manufacturing, including government regulatory issues, challenges of entering global market space, and other internal and external trials (Chiarini & Vagnoni, 2015). The key practice of the TPS was embedding continuous, evolving improvement throughout the entire system. The continuous-improvement system makes the system accountable for ongoing refinement of every element of the process (J. Li, 2013). To ensure all actors in the TPS play their role correctly, learning and increasing knowledge of TPS remains an evolutionary practice central to process of properly implementing quality production systems (Chiarini & Vagnoni, 2015).

Toyota Production System: Standardization

The TPS was a Japanese-crafted production system that links systems together by work and social organization operating structurally. The structural basis of the TPS was the balance of self-regulation, involvement, worker participation in the process, social integration of complex systems, and social control (Ciemnoczolowski & Bozer, 2013).

Lean manufacturing was a set of new practices, forms of work, and organized processes and was a specific collection of organized work formatted to operate with standard requirements of the production system's process chain (Renna, Magrino, & Zaffina, 2013).

I adopted Figure 1 from Monden's publication on the TPS which depicts the system overview of the inputs and anticipated outputs. Inputs from the TPS should improve the metrics of cost, quality, quantity, and respect for humanity (Ciemnoczolowski & Bozer, 2013). These serve as the relationship between the elements of organized process-structure development over time; for example, these relationships are operations and represent the effects of continuous improvement implemented to ensure teams are performing (J. Li, 2013). Continuous-improvement efforts lead to value-added changes in standardized production systems with routine operations, have immediate positive effects on manpower control, have direct effects on WIP, and help companies sustain inventory control (Ullah, 2014). Continuous-improvement efforts also positively affect organizations by reducing costs across the organization, eliminating unnecessary steps in the production process, and helping properly allocate human resources (Chiarini, & Vagnoni, 2015). As a dynamic process-capability approach in the structure of the TPS, process standardization and refinement efforts are constant and expected in the system (Schonberger, 2014). Staff identifies issues in all processes, standardized work procedures, and the workforce. Standards that provide the foundational structure needed to house the CIP control the dynamic environment (J. Li, 2013).

Major benefits of the TPS include constantly refining work and improving process standards to allow learning to grow and strengthen the workforce. At the center of the TPS are the core values CIP, learning, and standardization (Haider, & Mirza, 2015). The key objectives of process standardization in the TPS are operational standardization and production standardization (Teich & Faddoul, 2013). Standard operating routine sheets and standardized operations sheets drive operational standardization (Teich & Faddoul, 2013). Production flow controlled with the Kanban system for inventory control drives production standardization.

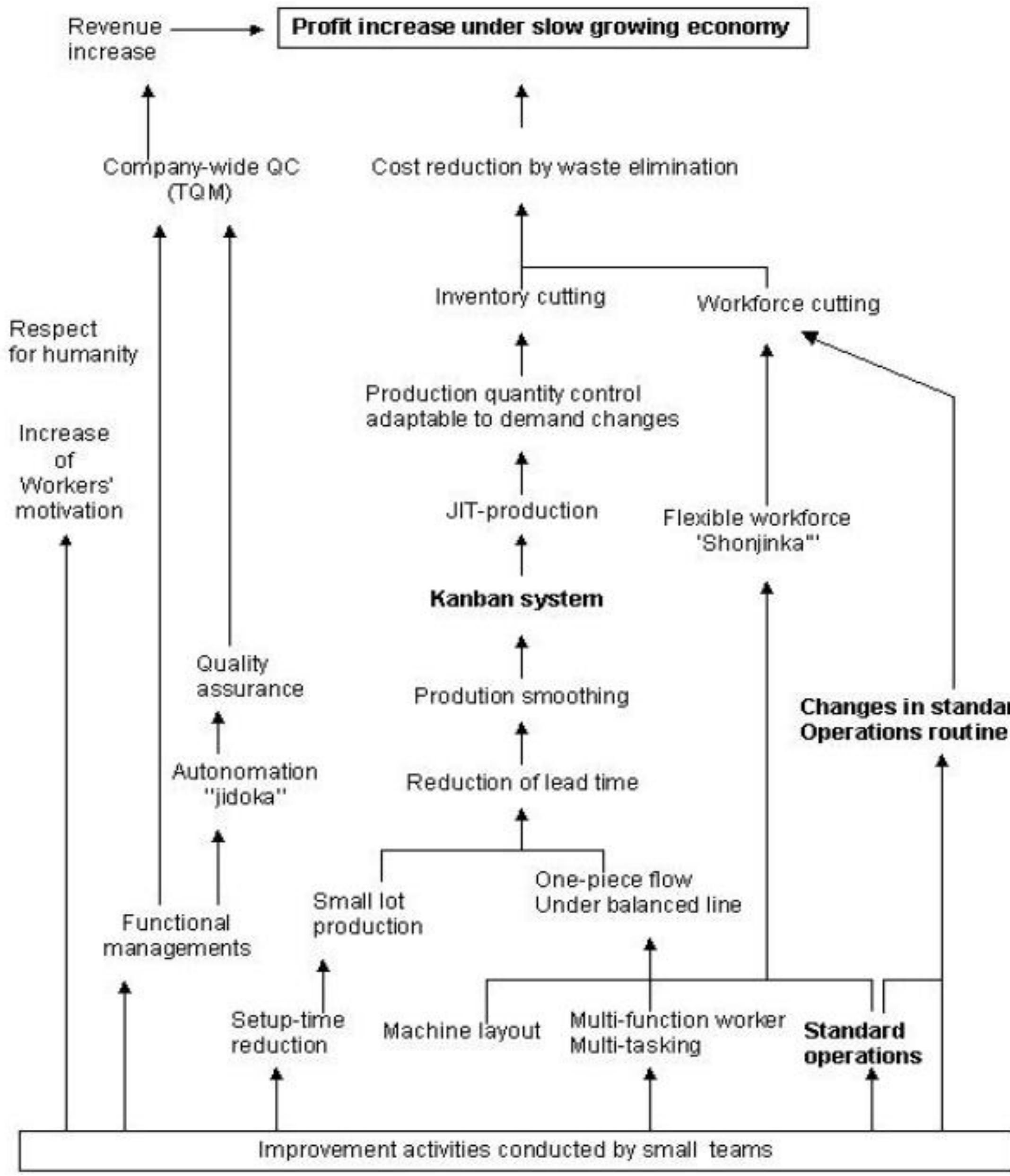

Figure 1. The Toyota Production System, an integrated approach to just-in-time (p. 130), by Y. Monden, 1983, Norcross/Georgia: Industrial Engineering and Management Press, (2nd ed.) Institute of Industrial Engineers**.** Reprinted with permission**.**

Toyota Production System: Standard Operations

The aim of the TPS in standard operations was to remove any type of waste in a complete system (Teich & Faddoul, 2013). Powell, Riezebos, and Strandhagen (2013) described the TPS as a quality production system for which the focus was doing more with fewer resources, including cycle time, inventory, space, labor, and capital expenditures. Implementing improvement activities in an organization's processes eliminates waste (Teich & Faddoul, 2013). Waste includes excessive inventory, overstaffing, improper allocation of resources at all levels, and any action in the process that was inefficient (Haider & Mirza, 2015). The TPS, as a quality production system, serves to eliminate waste, simplify procedures, and increase speed of production (Powell et al., 2013). The aim was also to set a standard system that minimized the number of workers in a production system by calculating the actual number of employees needed without sacrificing product quality and goals (Tsukada, 2013). A structured sequence and routine contain operations controlled using one operator and multiple machines (Tsukada, 2013). Toyota should design and organize these multifunctional operators so that each person allocated to the system positions all activity efficiently (Haider, & Mirza, 2015).

The TPS has three core goals to standardize operations. The first goal was to guarantee productivity levels through value-added work by developing standardized steps for every respective work routine, generating formal standard operations, and eliminating every amount of motion wasted by each operator. The second core goal was to guarantee balanced processes across lines in production timing and level loading. Simplifying task-by-time controls and efficiency balances processes (Chiarini, & Vagnoni, 2015). The third core goal of the TPS pertaining to standard operations was to guarantee a standardized amount of WIP (Concas et al., 2013) by simplifying and controlling process inventory or by reducing or not producing buffers in the system (Chiarini, & Vagnoni, 2015). Figure 2 demonstrates how Monden illustrated TPS standard operations (as cited in Clarke, 2005).

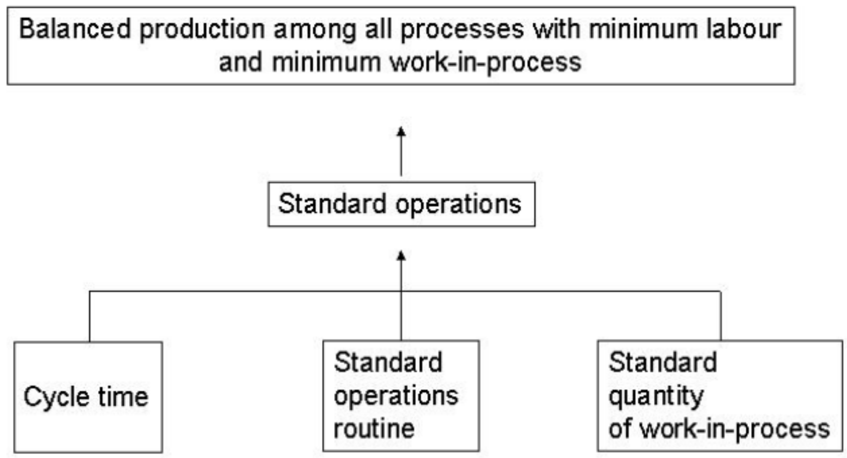

Figure 2. The Toyota Production System, An integrated approach to Just-in-time (p. 130), by Y. Monden, 1983, (p.146) Norcross, Georgia: Industrial Engineering and Management Press, (2nd ed.) Copyright 1994 by Institute of Industrial Engineers**.** Reprinted with permission**.**

Toyota Production System: Continuous Improvement Process

The continuous improvement process CIP was a key tool in the TPS methodology to eliminate waste in the process (Dahlgaard, 2014; Ham & Park, 2014). The term waste in the CIP applies to any non-value-added activity that interferes with the core goals of the TPS (Dahlgaard, 2014; Ham & Park, 2014). The CIP was a never-ending cycle that focuses the team toward increasing productivity and reducing every cost associated with manufacturing (Haider, & Mirza, 2015). Figure 3 illustrates how the TPS enacts CIP as an ongoing cycle (Clarke, 2005).

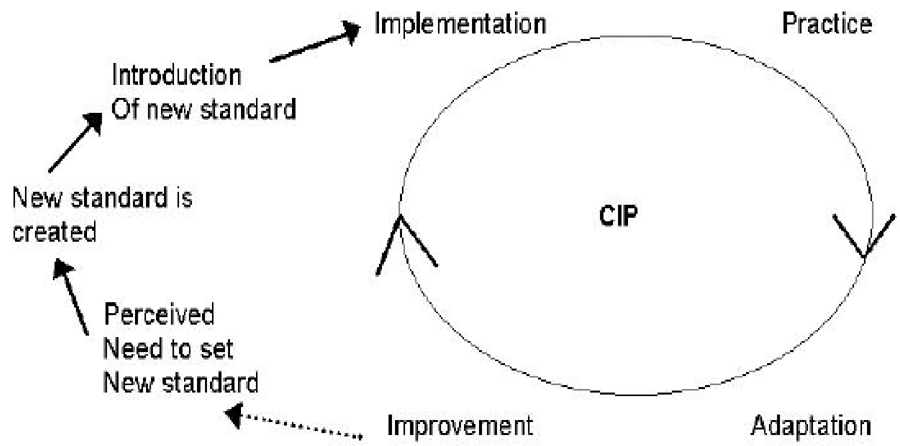

Figure 3. Toyota Production System standardization and the continuous improvement process. From *Automotive Production Systems and Standardisation: From Ford to the Case of Mercedes-Benz* (p. 106), by C. Clarke, 2005, Heidelberg, Germany: Physica-Verlag. Copyright 2005 by Physica-Verlag Heidelberg**.** Reprinted with permission.

Toyota Production System: Kanban

The Kanban system was part of the TPS and was central to providing information that cohesively delivers inventory control for production (Ullah, 2014). The Kanban system of inventory control can be used for material produced internally and exchanged between departments and as a method to deliver stocked inventory in a controlled manner to a production system (Ullah, 2014). Toyota leaders established the Kanban system and grounded it in the principles of the pull system (Ciemnoczolowski & Bozer, 2013). The pull system also effectively and efficiently transfers parts from one subprocess to another. Toyota’s TPS method also stage and input or withdraw materials from the Kanban area based on a manual card system or a computer-based system. Kanban systems serve as an information system that communicates every movement of every part throughout the production system and all processes (Ciemnoczolowski & Bozer, 2013). Kanban systems streamline every element of time and part quantities in the production system, thereby allowing inventory to control cash flow (Faccio et al., 2013).

During the evolution of automotive production-management models, organizations operated during economic growth, and mass production was the goal. However, the TPS included innovative and robust methods of production management. Toyota’s management staff has presented TPS as a systematic infrastructure by achieving maximum economic efficiency using minimal resources (Tsukada, 2013). Reducing all waste and all non-value-added activity was a core principle in the success of the TPS (Tsukada, 2013). Continuous improvement subjects all standards to regular evaluation and refinement for the next improvement opportunity (Berawi, 2015; Martínez-Juradoa et al., 2014). Unlike other production-management systems, the TPS sets a standard that allows continuous refinement and continuous improvement (Berawi, 2015).

Mercedes-Benz Production System

The value Mercedes-Benz Car Company gained from implementing the TPS into the MBPS was the developmental process of establishing best the methods. The best methods adopted into the MBPS are ideal methods used in the production system and human factors areas. The MBPS includes company-specific production solutions that Mercedes-Benz claim provide the best development and introduction to standard-production systems used in the automotive industry (Ha, 2013). The MBPS was a unified production system that evolved from a plant-wide production system that materialized following a merger between Daimler-Benz and Chrysler in 1998 (Clarke, 2005). Between the 1940s and the 2000s, the decision to develop the MBPS comprised knowledge gained from Toyota, NUMMI, Opel, Chrysler, Skoda, Audi, DaimlerChrysler, Mercedes-Benz, and Volkswagen. Even though Mercedes gained knowledge from all the organizations listed, the central evolution of production systems hailed from the framework developed by Toyota leaders to formalize the TPS (Ha, 2013).

Conversation and debates about the need to implement efficient production system have been ongoing since the early 1990s but Mercedes-Benz did not take them seriously until the mid- to late-1990s (Clarke, 2005). The phenomenon of organizational leaders implementing more efficient production systems surfaced in the Mercedes-Benz Car Company in the late 1990s. Created in 1999 and implemented in 2000, the MBPS began with the merger between Daimler-Benz and Chrysler in 1998. The merger partner, Chrysler Organization, had begun developing the COS. After the merger in the early 1990s, DaimlerChrysler identified issues with the product quality and decided to outsource the task of finding ways to implement an effective production system. To develop corrective actions between 1992 and 1994, Chrysler leaders embarked on an extensive benchmark research effort at Toyota, concluding that Chrysler leaders should implement a production system modeled on the TPS. The implementation of the 1994 improved COS took place between 1995 and 1996 (Clarke, 2005).

The Daimler-Benz and Chrysler merger raised many issues in establishing a company-wide production system (James & Jones, 2014). During the merger, issues that arose between the acquisition groups included brand specifics and control. The parties disagreed about whether to call the new system COS or MBPS (Clarke, 2005). The board of directors established the name DCOM in 1999. Immediately following ratification of the DCOM, DaimlerChrysler approved the MBPS for use in all Mercedes-Benz passenger plants worldwide. DaimlerChrysler modeled the MBPS on the DCOM by using management and representative groups of the works council to help drive the change. The group ratified the final agreement to use the MBPS in 1999 and implemented it at the beginning of 2000. The evaluation and implementation schedule entailed a three year period from January 2000 until December 2002 (Clarke, 2005).

The research of TPS presented in this research was important because forms the direct connection between TPS and MBPS. Mercedes-Benz leaders used Toyota's manufacturing system as a benchmark model with the goal of potentially establishing success in a similar way (James & Jones, 2014). The aim of this research study was to ensure the reader was well versed in the system provided by Toyota and was able to understand why Mercedes-Benz chose this model as a best method for MBPS. The focus of the MBPS was three core characteristics that made the manufacturing system specific. The first core focus of the MBPS was examining the form and function of the production system and providing the main connection between the MBPS and the TPS (James & Jones, 2014). The second core focus was implementing the process of institutionalizing key standards in individual Mercedes-Benz plants. Third, the focus of MBPS ensured that workers learned the elements needed to run the system by controlling the actors on the shop floor (James & Jones, 2014).

To achieve a task-based foundation, I documented analysis and quantitative empirical research grounded in formalizing the implementation phases of the MBPS (N. Kumar et al., 2013). This proposed study took place primarily at one Mercedes-Benz plant located in Untertürkheim in one production center. As the research progresses, the code used for the center was Center Z. The three main production centers were Departments/Subcenters A, B, and C. This research took place at the central departments of work policy located at the headquarters of Daimler-Chrysler in Möhringen while an international meeting was in session with internal teams (Clarke, 2005). Next, I briefly describe the organizational structure of the MBPS.

Mercedes-Benz Production System: Organizational Structure

The plant used in the development of the MBPS was in Untertürkheim. The plant facility covers an area of 2,025,000 m^2, the production area designated for production was about 797,400 m^2, and workforce was around 20,758 employees. This plant provides powertrain components such as axles, engines, and transmissions for all Mercedes-Benz passenger-car models. The plant organizational structure has centers flowing down into subcenters, subcenters flowing into cost centers, and cost centers flowing into workers (see Figure 4). The management levels descend from the plant manager (E1) to the center manager (E2), the head of department (E3) leading at the subcenter level, team leaders (E4) leading at the subcenter with the head of the department, supervisors (5) at the cost-center level, and workers operating the plant. Production areas are located in production centers; every center was separated into production departments. The production departments are called subcenters, and every subcenter was called a cost center. The organizational structure was predominately in use at production plants of DaimlerChrysler, and the roles and responsibilities describe the plant manager and management level at headquarters as equal.

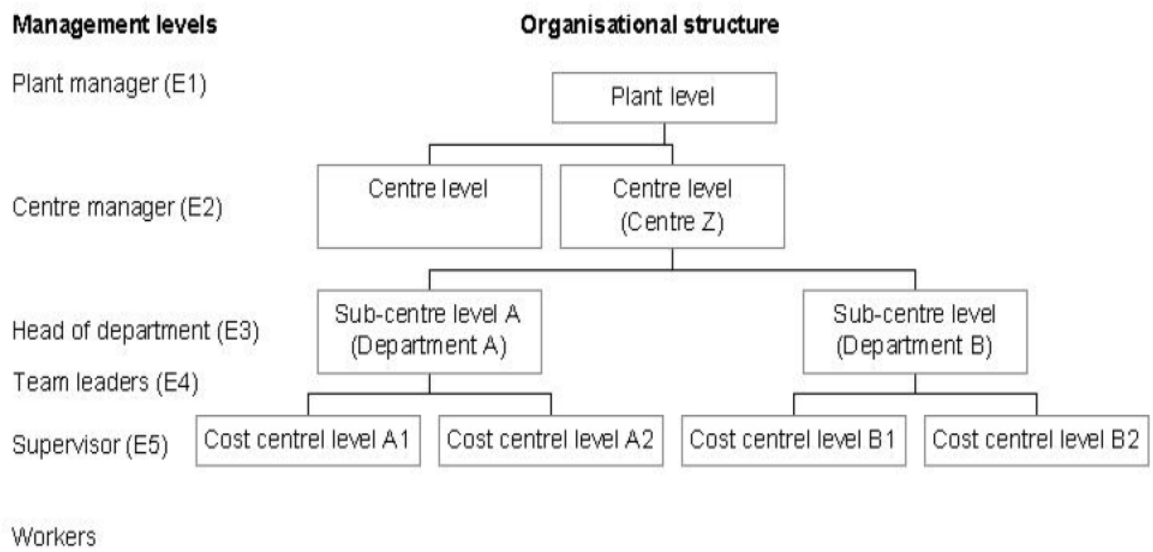

Figure 4. The Toyota Production System. An integrated approach to just-in-time (p. 130), by Y. Monden, 1983, Norcross, Georgia: Industrial Engineering and Management Press, 2nd ed., Copyright 1994 Institute of Industrial Engineers**.** Reprinted with permission**.**

The Mercedes-Benz Car Company lean-transformation effort began mid 1990s in efforts to reinvent the quality of the organization (Follmann, Laack, Schütt, & Uhl, 2012). Also, the organization continued to have a marked impact in the car industry (Follmann et al., 2012). The leaders at Mercedes-Benz Car Company decided to approach new product development by evaluating all components of the complete production system and benchmarking the system to the TPS (Haider, & Mirza, 2015). The company selected the TPS method as a template for the MBPS (Follmann et al., 2012). Implementing the MBPS in the product-development process provided an infrastructure for developing new product (James & Jones, 2014). The company leaders also worked to provide fundamental necessities that optimized the complete production system in its entirety (James & Jones, 2014).

The MBPS used TPS management tools as a closed-loop system that established the departments named MBPS Training and MBPS Support (Follmann et al., 2012). The groups supported as a form of standard control for the company to analyze business processes, interface with leadership, and manage transformation projects. These groups also focused on safeguarding the robust systems implemented in Mercedes-Benz Car organization would achieve a concept termed model-factory standard by stimulating processes to develop a common training content that coincided with the current knowledge of participants (Follmann et al., 2012).

Full-scale knowledge of new product-development and production systems must include identifying every instance of waste, non-value-added, or productivity-hindering task in the process from concept and design (Cooper, Edgett, & Kleinschmidt, 1998). Organizational leaders must be aware of advanced product and process development. Methods must be capable of reducing development cycles, sustaining engineering, and outputting quality to maintain a competitive edge (Cooper et al., 1998; Ţenescu & Teodorescu, 2014). New product-development life cycles are optimal when making choices on behalf of organizations. Benefits of Mercedes-Benz MBPS efforts assisted its leaders obtain long-term and short-term production output in product development and assembly phases (Cooper et al., 1998).

Cycle Time: The Independent Variable

The focus of this proposed quantitative comparative research study was how independent variables affected productivity as the dependent variable. I examined the effects cycle-time variation has on productivity. Kumar and Kumar (2014) expressed that cycle time was important and should be a practical option when organization leaders are working to improve efficiency, productivity, cost, and customer responsiveness. Cycle time was a vital component in creating and maintaining quality production systems. Productivity was the independent variable in this quantitative comparative research study. Quality-production-system tools should help to reduce cycle time in automotive-production plants. Proper implementation of quality production systems positively affects assembly-line balancing, avoids process delays, and improves production cycle times (Kumar & Kumar, 2014).

Cycle time was an interval of time that sequentially groups actions placed in a specific series embedded in a quality management system. As consumer demands increase and better-quality output increases, cycle time was one element immediately affected and controls whether a quality production system was successful (Kumar & Kumar, 2014). Cycle time affects quality production systems through annual forecasts, employee headcounts, time-to-market, and quality-system deployment (Kumar & Kumar, 2014).

Performance metrics such as cycle time lack a full understanding of their impact on quality production systems (Godinho Filho & Uzsoy, 2014). Cycle time was the primary performance measure when studying quality production systems effectively. It was imperative to reduce cycle time in quality production systems because productivity increases concurrently. Improvements in cycle time produce positive results in productivity by lowering WIP, reducing the operating capital needed, helping leaders of automotive companies adapt to market changes more easily, and increasing process yields (production output). The TPS also uses cycle time reduction as a relevant source to eliminate waste in quality production systems (Godinho Filho & Uzsoy, 2014). Reduction in cycle time increases productivity in quality production systems (Saraswat, Kumar, & Kumar, 2015).

Cycle time was important to help develop each step in the quality-production-system process. Cycle time was the actual process time and was graphically comparable to takt time (Saraswat et al., 2015). Takt time was a standard reference for level loading and balancing the quality production system (Ali & Deif, 2014; Saraswat et al., 2015). The expectation in a research study consisting of takt time in a production system was to be as balanced as possible in a comparative analysis (Ali & Deif, 2014; Saraswat et al., 2015). Adding WIP can produce adverse effects to cycle time in a quality management system (Hsieh, Chang, & Chien, 2014).

The focus of the proposed quantitative comparative research study was on how the independent variables of cycle-time variation, employee-headcount variation, and KPIs affect productivity as the dependent variable. Directly related to this research study, I examined the negative and positive effects of cycle time on productivity. Hsieh et al. (2014) further explained that increasing the WIP increases cycle time, delays delivery time, and potentially affects a quality management system negatively.

Summary and Conclusions

Chapter 2 of this quantitative, comparative research study included a description of the major theme of the study, which was TPS, thereby explaining the empirical framework as evidence of the MBPS. Leaders at the Mercedes-Benz Car Company developed the MBPS by building on the TPS. The discussion demonstrated the effectiveness of benchmarking the successful TPS. This chapter indicated how the proposed quantitative comparative research study filled at least one of the gaps in the literature and extended knowledge in the discipline of quality production systems by describing the new framework of the MBPS. The study involved an attempt to evaluate the effect of the independent variables cycle-time variation, employee-headcount variation, and KPIs on the dependent variable, productivity, between 1999 and 2017. The specific problem addressed the gap in research on how cycle-time variation, employee-headcount variation, and KPIs affected productivity after implementing the MBPS.

The historical evolution of automotive manufacturing methodologies is rich and has deep roots across the global marketplace through the evolution of production systems established and implemented over the past 100 years. Automotive production systems that progressed and advanced through many generations of specific production systems influenced the development of the MBPS. This production system transition involved the following organizations and manufacturing methods: Ford mass-production assembly lines, Taylor’s time and motion studies, lean manufacturing, process-oriented production systems, and total-quality-management-based International Organization for Standardization models (Martínez-Juradoa et al., 2014). The systems that did not emphasize quality control led to the development of the TPS, which considers quality control, continuous improvement, and the optimization of the production system (Sahno, Shevtshenko, & Zahharov, 2015). In turn, the Mercedes-Benz Company leaders elected to implement the specific production-system methodologies developed by the TPS (Lu, 1989; Sahno et al., 2015).

The findings from this quantitative comparative research study may improve the significance of the Mercedes-Benz Car Company by implementing the TPS methods through the MBPS. Recommendations from this study will further provide relevance of the framework that defines TPS and the progressive impact its development has on the automotive industry as a best method. The MBPS serves as an improvement to the quality production systems at Mercedes-Benz cars. The TPS philosophy established the guidelines used as a strong ideal and implemented as a technique to produce the MBPS (Lu, 1989). This research explained the benefits received by MBPS after modeling the proven methods of the production system methodology created by Toyota.

Understanding the TPS provided basic knowledge of why Mercedes Car Company leaders chose the TPS model in creating the MBPS (Lu, 1989). This quantitative comparative research study included transitional information that fills a gap in the literature on the quality production system produced by Toyota. The methodology of the study appears in Chapter three. This production system method established a platform from which the MBPS can receive recognition in research studies by modeling the continuous-improvement efforts indicated through TPS (Begam, Swamynathan, & Sekkizhar, 2013). Based on effective accomplishments and developments that evolved from the TPS, the MBPS model may improve the effectiveness of the organization’s production system, productivity, infrastructure, quality output, and costs (Kim, 2013). Next, Chapter 3 discusses the research method and the rationale for the research study.

Chapter 3: Research Method

Introduction

The purpose of this quantitative, comparative study was to investigate the effect of the independent variables. The specific problem was the gap in research on how cycle-time variation, employee-headcount variation, and KPIs affected productivity after implementing the MBPS. This study included survey questions circulated to a general population in a randomized distribution of employees of Mercedes-Benz. The survey focused on the impact on the dependent variable, productivity, after implementing at Mercedes-Benz the new MBPS quality system that was modeled on the TPS.

Research Questions and Hypotheses

1. How does the variation in cycle time (production time it takes for an operator to complete a job) affect the productivity of Mercedes-Benz cars?

$H1_0$: Variation in cycle time (production time it takes for an operator to complete a job) does not affect the productivity of the Mercedes-Benz Car Company.

$H1_a$: Variation in cycle time (production time it takes for an operator to complete a job) does affect the productivity of the Mercedes-Benz Car Company.

2. How does the variation in the number of employees (total number of employees in a production process) affect productivity in the MBPS between 1999 and 2017?

$H2_0$: Variation in the number of workers (total number of employees in a production process) does not affect the productivity of the MBPS between 1999 and 2017.

H2_a: Variation in the number of employees (total number of employees in a production process) does affect the productivity of the MBPS between 1999 and 2017.

3. What are the key performance indicators (KPIs) (data used to review productivity) in the MBPS that affected productivity between 1999 and 2017?

H3_0: KPIs (data used to review productivity) did not affect productivity in the MBPS between 1999 and 2017.

H3_a: KPIs (data used to review productivity) did affect the productivity of the MBPS between 1999 and 2017.

Research Design and Rationale

This study included a quantitative, comparative analysis. Quantitative research entails an analytical methodology of research and describes reality as objective; it is logical and includes causal variables. The dependent variable was productivity, and the independent variables were cycle-time variation, employee-headcount variation, and KPIs. This study included a nonexperimental evaluation of the effect of the dependent variable caused by the independent variables after implementation of the MBPS to observe its impact on the Mercedes-Benz Car Company productivity over a period of18 years. Researchers respect nonexperimental designs when used to perform studies comparable to experimental research designs. Researchers who carry out nonexperimental designs effectively can identify causal relationships from independent and dependent variables. Observational research studies include comparisons and design duplication to gain in-depth knowledge of a research study. Researchers use nonexperimental and empirical data to eliminate bias and to provide validity for research studies. Researchers can also use experimental research evaluations to investigate hypotheses using nonexperimental designs to describe a phenomenon or experimental design. While developing the research design methodology, it was imperative that researchers choose the correct research methodology. No clear distinction exists indicating one research design was better than another; however, as noted previously, it was important for a researcher to select the most appropriate research design. The study included 18 years of data between 1999 and 2017 after the implementation of the MBPS.

In this comparative research study, I connected the research design to the research questions by aligning them with the research problem under study. I have designed the study to answer the following questions:

1. How does the variation in cycle time (production time it takes for an operator to complete a job) affect the productivity of Mercedes-Benz cars?
2. How does the variation in the number of employees (total number of employees in a production process) affect productivity in the MBPS between 1999 and 2017?
3. What are the key performance indicators (KPIs) (data used to review productivity) in the MBPS that affected productivity between 1999 and 2017?

In this quantitative comparative research study, I observed the cause-and-effect output that affects the dependent variable, productivity. The cause-and-effect impacted results from the independent variables cycle-time variation, employee-headcount variation, and KPIs. I explored the 18-year period between 1999 and 2017 that followed implementation of the MBPS in 1999. This study only included Mercedes-Benz cars.

I investigated KPIs in the MBPS through quantitative research. I distributed a research instrument to a population of employees of Mercedes-Benz cars. I chose this sample group because its members represented employees with experience working on the shop floor or are familiar with quality production systems at Mercedes-Benz cars. I used the survey to collect data from employees most acquainted with the shop floor of Mercedes-Benz cars following implementation of the MBPS. Survey participants met the following conditions: they worked daily in productivity-related activities and with the independent variables cycle time and employee headcount. Participants had the following job roles: operation manager, plant manager, manufacturing engineer, or shop-floor worker.

Resource constraints consistent with the design choice are weaknesses that are not in my control and could affect conclusions from this research study. These constraints were cycle time, productivity, and employee headcount and how they relate to the accuracy of available calculations. This study only involved examining the variables cycle time, productivity, and employee headcount, thereby narrowing the focus and constraining the possible effects. Because this study was taking place in the early stages of available research, considerable learning limited my research effort. The lack of research publications and data available provided chances to explore the effectiveness of implementation, and current productivity has expanded this subject. The research process model for this study is in Figure 5.

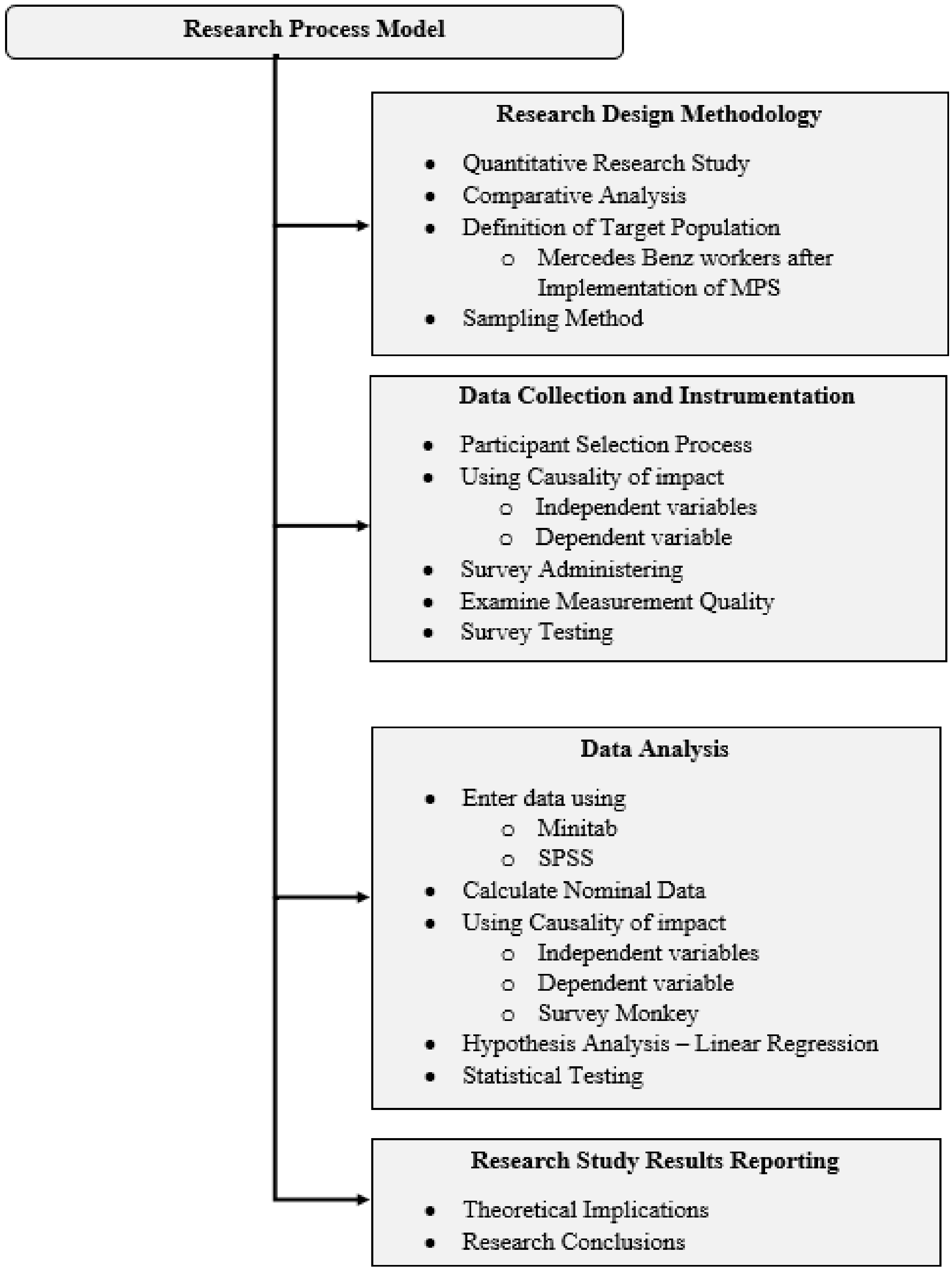

Figure 5. Quantitative, comparative study research process model.

Methodology

Methods used in the data analysis involve detecting datasets that align with the research study and meet the requirements for testing the specified hypotheses. It was important to reference applicable methodologies and theories of other researchers using datasets from other research studies. This research study included data collected from Mercedes-Benz cars survey questions that collected data by surveying a population of operation managers, plant managers, manufacturing engineers, and shop-floor workers.

The inferential process formed a foundation for this quantitative research study based on causation between the independent and the dependent variables. The model assessed the effect on productivity of the quality production system of Mercedes-Benz cars from 1999 to 2017. The model assessed also entails reviewing data regarding KPIs in the MBPS and creating a survey research instrument.

Population

The target population consisted of Mercedes-Benz cars employees who fill roles of operation managers, plant managers, manufacturing engineers, and shop-floor workers. The target population consisted of employees of Mercedes-Benz between 1999 and the present. The target population worked directly in the MBPS after implementation in 1999. Participants are not required to have worked in the MBPS for the total amount of years between 1999 and 2017 to take the survey. The goal was for Mercedes-Benz cars employees with work experience in the MBPS at some point between 1999 and 2017. The population for the study varied in gender, occupation, years working for the company, age, ethnicity, and education level and background.

Sampling and Sampling Procedures

This quantitative comparative research study included a purposive, nonrandom sampling strategy. Researchers commonly use purposive sampling in research studies when a specific group of employees are most suitable for responding to the research problem (Tong, Niu, Xie, & Peng, 2014; Wagner & Esbensen, 2015). Employees in the roles outlined above have a better understanding of the research topic and are more appropriate than randomly selected individuals to assist in answering the research questions (Tong et al., 2014; Wagner & Esbensen, 2015). I chose a purposive, nonrandom sample because Mercedes-Benz do not use the MBPS in all automotive divisions throughout company.

I sent the survey and study information to potential research participants through SurveyMonkey and face-to-face interviews if necessary. The initial question of the survey asked if participants worked in the Mercedes-Benz Car Company between 2000 and 2013. If participants respond no, then the survey thanked them for their time and ended. This research study excluded employees from the survey who only worked in the Mercedes-Benz Car Company before 1999.

The sampling frame for this research included data from Mercedes-Benz cars collected through a survey that targets employees in particular jobs roles who worked for the company between certain years. This selection of employees reflected the best group to observe in the study because the nature of survey pursued individuals that have knowledge of the Mercedes-Benz company to answer the research questions. This group was the most relevant for the sampling conditions after implementation of the MBPS.

I chose the sample size by defining the target population, sampling frame, and sampling design and by considering population size, number of variables, and selected confidence level (Ortega, Cordeiro, Hashimoto, & Cooray, 2014; Zhou & Li, 2015). The confidence level used in a quantitative research study was normally 95% (Dattalo, 2008), which indicates the researcher was 95% assured that results produced by the study's sample represent the larger population (Hair, Black, Babin, & Anderson, 2010). For this research study, I used G*Power Version 3.1.9.2 to calculate the sample size required based on a completed regression analysis (Ortega et al., 2014; Zhou & Li, 2015). Using a significance level of 5% (alpha) for hypothesis testing, a 95% confidence interval, three predictor (independent) variables, and one response (dependent) variable, the sample size of 33 is necessary to detect an effect size of 0.35. An effect size of 0.35 is high, 0.25 is medium high, 0.15 is medium, and 0.12 is low. The sample sizes at each range are in Table 1.

Table 1

Ranges Evaluated for Sample Sizes

Effect size class	Effect size (f^2)	Total sample size	Critical *t* test
Low	0.12	92	1.66216
Medium	0.15	74	1.66660
Medium high	0.25	45	1.68195
High	0.35	33	1.69726

Note. Confidence interval = .95; significance level = .05.

Data Collection

In compliance with Walden University, researchers must complete IRB guidelines prior to collecting any research data. After I receive consent from the IRB to collect data, I begin collecting data using SurveyMonkey. Prior to beginning the survey, a participant agreed to a statement of consent for participation. A copy of the consent letter and statement was in Appendix A. The letter of consent included the purpose, procedures, and potential benefits involved in the research study. Compliance with the statement of informed consent indicated that potential participants understand participation was voluntary. I also made certain potential participants had the option to withdraw from the study at any time. The informed consent letter included details of the research study and its purpose. Further, the letter explained to survey participants that the information was anonymous.

Information displayed by SurveyMonkey shows only results and excludes research participants' identities, which makes participants anonymous to the researcher. This study used a survey questions to answer questions regarding KPIs in the MBPS that affected productivity from 1999 to 2017. Distributing the survey questions to a general population of employees of Mercedes-Benz cars occurred using SurveyMonkey. This data collection effort was centered on receiving information from operation managers, plant managers, manufacturing engineers, and shop-floor workers. The target group provided the most valuable responses based on their daily involvement in manufacturing activities related to elements such as cycle time and employee headcount.

Operationalization of Constructs

This research study investigated casual impact between three independent variables, and one dependent variable a research instrument. A structured survey questionnaire provided a basis for responding to the research questions. I have adopted two published surveys for the research study, and each survey addressed the dependent and independent variables. A brief description of each instrument and letters of permission from instrument publishers was in Appendix B.

The dependent variable was productivity. The independent variables are cycle-time variation, employee-headcount variation, and KPIs. The survey questions were comprised four major sections and one minor section. The major sections were productivity, cycle-time variation, employee-headcount variation, and KPIs; the minor section had general questions.

I measured the dependent variable in the research study, productivity, using questions selected from published surveys adopted from Opara (1995) and Stout (2014). Both researchers used a Likert-type scale to measure the performance of productivity in their studies. Q. Li (2013) identified disagreement in the research community about the efficacy of Likert-type scales in providing the interval properties assumed. Researchers respect and use the Likert-type scale globally. Pioneered by Likert, the scale has interval properties with a capability map underlying latent constructs (Q. Li, 2013). A copy of the survey questions that I will use with a Likert-type 5-point scale appears in Appendix C.

Data Analysis Plan

The data analysis plan of this research centered on five focal points: data preparation, data investigation, data analysis, data analysis representation, and research outcome interpretation (Stout, 2014). Research data preparation consisted of making data useful for SPSS by formatting and removing data errors that occur during entry. I investigated the survey data output using SurveyMonkey by exporting and formatting survey data for use in SPSS. After preparing the data, I examined the data using descriptive statistics that consisted of frequencies, means, and standard deviations through visual data assessment and studying broad trends. I completed ordinal-regression calculations using SPSS. Ordinal regressions were appropriate for this research study because they generalize binomial logistic regression, and researchers can apply them when using dependent and independent variables on a Likert-type scale (Perez-Ortiz, Gutierrez, Hervas-Martinez, & Yao, 2015).

The need to determine the relationship between a single or multiple independent variable and a single or multiple ordinal dependent variable supports the appropriate use of ordinal regression (Laerd Statistics, 2015). Ordinal regression has four assumptions. First, on the ordinal level, researchers measure the dependent variable. In the ordinal state, I had one dependent variable. The dependent variable showed how the three independent variables affected productivity. The first assumption was that data presented in the regression equation was autonomous or independent. This research study evaluates the MBPS after implementation in late 1999 and includes a longitudinal period from 1999 to 2017 using cycle-time variation and headcount variation as independent variables and productivity as the dependent variable. This quantitative comparative investigation involved examining the impact independent variables have on the dependent variable.

The second assumption was that independent variables were continuous, ordinal, or categorical in their classification (Pedhazur, 1997). The research study had three independent variables that influenced causation in the research study, and they are ordinal variables. The second assumption was that a linear relationship existed when I plot the data of the research study on a graph using the data in the regression equation. To test and verify the resulting comparative impact between the independent and dependent variables, I graphed the projected data and experimental data to test the assumption. Evaluating the output data graphed on different type tables, I was able to study the alignment of the data's linearity.

The third assumption stated that the research study does not have multicollinearity; therefore, two or more independent variables had a low probability of correlating with each other (Pedhazur, 1997). Multicollinearity, also called collinearity, was a high correlation between two independent variables in a multiple regression model. Collinearity means that one independent variable can linearly predict another. (Pedhazur, 1997). I performed collinearity statistics and examine the results for variance inflation factors to identify if correlation exists. The third assumption was that the distribution of data was normal (Green & Salkind, 2008). When researchers study research data on a normal distribution curve, histograms may indicate the possible outliers in the research test data and presented a platform to test the assumption. The platform of evaluating the normal distribution curve gives researchers an opportunity to review the kurtosis presented through visual analysis. Kurtosis allows researchers to see the data through the peak sharpness of a distribution frequency study the following: heavy tailed, light tailed, and outliers (Green & Salkind, 2008). The heavy tailed, light tailed, and outliers are explained clearly in the next few sentences. High-kurtosis data arrangements usually include outputs of heavy tails or outputs displaying outliers. Low-kurtosis data arrangements usually present outputs of light tails or outputs displaying no outliers. Confirming the linearity of the data guaranteed this in the study.

The fourth assumption of the research study was about proportional odds. The independent variables have matching effects for each cumulative split of the ordinal dependent variable (Pedhazur, 1997). This research study had one dependent variable and viewed one trial of the cumulative split to test proportional odds. If a study result has a *p* value greater than the .05 necessary when running a chi-square test, that result was the same as rejecting the null hypothesis (Pedhazur, 1997).

Green and Salkind (2008) recognized statistical assumptions generally related to research studies using linear regression analysis as the following: homoscedasticity of error variance, independence, linearity, and normality. It was normal for researchers to recognized threats to multiple regression as outliers and multicollinearity, as discussed earlier in this section (Green & Salkind, 2008). The fourth assumption indicates that the variance of error in research was likely to be a constant for the variables of the study. When graphing the data of the independent variables and the dependent variables, the linear regression was likely to display homogeneity. The goal was to evaluate the standardized residuals relative to the standardized linear regression output and analyze homogeneity (Green & Salkind, 2008). Homogeneity of variances, also widely known as homoscedasticity, was the method of testing if a study's null hypothesis and determine if the null hypothesis should be rejected or accepted (Green & Salkind, 2008).

The effort to test the null hypothesis included an opportunity to see if the population and sample of the research study's variances were equal. Another name for the test was Levene's test for quality of variances (Green & Salkind, 2008). If the graphed research data present a nonrandomized scattered pattern, then the researcher can determine that there was a violation in homogeneity or heteroscedasticity. A violation in homogeneity or heteroscedasticity occurs when the sequence of the error size results was different within independent variable values. Outliers in linear regression also present issues or threats if they arise during the regression analysis of the research study. When outliers are present in data, there was a shift of the data's trend line in the direction opposite from the majority of the study's dataset (Green & Salkind, 2008). Outliers also refer to graphed data points for which the *y*-axis value or values do not trend similarly to the remaining data. The study's analysis also underwent analysis for univariate outliers with a focus on the dependent variable as well as multivariate outliers with the dependent variable. Univariate outliers refer to data with values that are extremely risky when compared to the majority of the dataset and are relative to one variable. Multivariate outliers refer to data that contain a combination of values in a study that are extremely risky when compared to the majority of the dataset and are relative to two or more variables. Both univariate outliers and multivariate outliers can affect a research study when performing results of statistical analysis and can be seen using scatterplots and other types of graphed data. Multicollinearity was also an assumption, as explained earlier in this section by Pedhazur (1997) and expressed by Kock and Lynn (2012) as a threat to multiple regression modeling. Kock and Lynn indicated that multicollinearity was present if models that contain two or more independent variables have a redundancy phenomenon.

As a tool used to analyze discrete and continuous data, researchers often use regression analysis in academic research and social science fields of study (Tonidandel &

LeBreton, 2011). Multiple regression analysis was useful for identifying independent variables in quantitative research studies when assessing the quantitative variable in a comparative investigation with other influences (Cohen, 2003). Cohen (2003) described multiple regression analysis as suitable when researchers do not control independent variables and when independent variables properly respond as an effect on the dependent variable**.** Research also describe multiple regression analysis in graph form by displaying constant slopes in a straight line on a graph, conditional, and curvilinear association between multiple variables. Variables in research studies should be naturally occurring to ensure the study exhibits generalized independent variables that show causal impact to the dependent variable. Researchers must be sure to investigate items such as personality gender, and time spent with leadership because these show comparable independent variables, uncontrolled independent variables (Cohen, 2003).

The researcher must identify outlier data when using multiple regression analysis, as it was important to understand significant parameters in the data to alleviate the risk of bias in the research (Alma, Kurt, & Ugur, 2011). SPSS, MiniTab, and other software packages are important in furthering the effectiveness of a study. Missing data also could potentially influence the resulting outcome data differently from the expected outcome (Hawthorne & Elliot, 2005). Researchers handle missing data in a few different ways in research studies including the following: software systems, mean substitution, and multilevel individual substitution (Anderson, Tathum, & Black, 1998).

The premise of this research study was to examine the hypotheses of the independent and dependent variables using linear regression analysis. The proposed quantitative research study included linear regression to investigate the comparative relationship of cycle-time variation, employee-headcount variation, KPIs and productivity. The dependent variable was productivity. The independent variables, also known as predictor variables, was cycle-count variation and headcount variation. The center of this study focused on impact to productivity after the implementation of the MBPS.

Researchers who use r^2 can determine the amount of variance credited from a dependent variable to an independent variable. The significance r^2 measures how closely the data align with the fitted regression line. Researchers can also use the *t* statistic when determining the significance of an independent variable (Cook & Campbell, 1979). Beta coefficients serve to describe the linear comparative relationship of two variables. The mathematical model for simple linear regression was as follows:

$$Y = \beta_0 + \beta_1 X + \varepsilon,$$

where β_0 and β_1 represent the constants referred to as model regression coefficients or parameters, and ε represents a random disturbance of error (Cook & Campbell, 1979). The assumptions described in the assumption section of this research study relative to the investigated observations challenged this linear equation. The assumption section of this research also indicated that studying a range of observations delivers a true representation of the relationship between *X* and *Y*. Therefore, *X* and *Y* are a linear function of each other and ε focuses on the discrepancy of the measurement in the approximation (Cook & Campbell, 1979).

Using the slope helped to determine the nonlinearity of the relationship between *X* and *Y*. The relationship of nonlinearity does not have a constant slope. When there was a relationship between *X* and *Y*, then there is usually a linear relationship. To determine if the strength of the relationship was weak or strong, I evaluated the correlation. Researchers use correlation to tell about relationships between variables. Correlation also indicates whether a relationship was positive or negative and the strength of the relationship. If the slopes rise or fall together, then the correlation was positive. If the slopes increase in the independent variables and decrease in the dependent variable, then the correlation was negative. When a relationship exists between *X* and *Y*, then this usually indicates that there is a linear relationship. Nonlinearity usually occurs when there is a minuscule or no relationship between *X* and *Y* values.

Threats to Validity

Threats to validity in this comparative research study may include cross-sectional analysis, internal validity, external validity, and construct validity. Researchers face different elements of validity, depending on the type research study. Researchers must be cognizant of the options of validity that challenge the value in strength and robustness guaranteed in the research effort. Researchers should address validity properly during the research process. Researchers who properly respond to validity concerns can establish generalization in research**.** Though validity was one of the challenges in research, the next topic of discussion was on how validity relates to this study.

Threats to validity in this comparative research study may include the use of cross-sectional analysis as a type of observational research predicated on analyzing data received on a population or some subset under investigation. There was also potential for a single limitation regarding nonresponse bias. Leaders at Mercedes established the MBPS by modeling the TPS methodology developed and validated by leaders at Toyota. Many organizational leaders consider the TPS to be the superior working production model established through implementing lean-manufacturing tools and optimal methods that led to an increase in productivity. This level of selectivity creates threats to validity and could potentially develop conditions that would make the research study more susceptible to nonrepresentative responses in the study. In this research study, the goal was to avoid limitations in the study that would result in threats to external validity. Cook and Campbell (1979) expressed the meaning of validity as an estimate that was the best representation of facts or inaccuracies of inferences or predictions with some research. Cronbach (1971) referred to validation as a methodology that contains a research effort that researchers could potentially use for examining research hypotheses. I grounded this research effort on the effects caused by the independent variables cycle-time variation, employee-headcount variation, and KPIs regarding the dependent variable, productivity, from 1999 to 2017. The significance of studying the MBPS from 1999 to 2017 helped to ensure stability in the process after the implementation of MBPS in 1999.

External Validity

Researchers can identify threats to external validity through selection bias. Selection bias occurs when the research sample under investigation was not representative of the desired population. In the event selection bias was present, it was highly probable that researchers cannot successfully argue that the research results are generalizable to the larger population (Bagozzi et al., 1991). In spite of opportunities for bias, I minimized the risk of the effects of sample selection bias by ensuring the sample comes from the population of Mercedes-Benz associates after MBPS implementation.

External validity was significant in scientific research in the social sciences. External validity relates to generalization with causal inferences. The basis of external validity was an experimental investigation in an experimental research study. Researchers predicate generalization in research on a general simplification of the results of the research for situations and individuals. Though threats to external validity have a significant impact on research generalization, researchers can manage and neutralize them. Offsetting the threats to external validity was essential to avoiding the unwanted effects of unjustified generalization. When performing research, researchers must understand the factors involved in the causes of threats to external validity in research. Threats to external validity can be situational, effects from pretests, effects from posttests, aptitude, and reactivity**.** Situational threats exist in every condition that could affect a study and restrict the generalization, pretest threats occur when the causal effect occurs only when performing pretests and restricts generalization. Posttest threats occur when the causal effect occurs only when performing posttests and restricts generalization. Aptitude threats occur when the subject's treatment may intermingle with the independent variable and restricts the generalization, and lastly, reactivity threats occur when the state of generalizations are interruptive to the causal impact based on the situations or conditional settings (Cook & Campbell, 1979). External validity occurs in systematic research that reflects causal impact of the independent variable that restricts generalizations (Cook & Campbell, 1979).

External validity in this research produced results from the study that can be generalized and used in other situations. Threats to external validity refer to disputes identified within the data collection choices. Bias could also include selection bias, which potentially happens during the data collection process. In addition, selection bias can take place when the sampling process was in the investigation phase of research and the sample was not representative of the population under study. If selection bias occurs while a research study was in progress, a researcher cannot confidently claim that the research study's results are generalizable and comprehensive to a majority population (Bagozzi et al., 1991). This research study was generalizable by reducing the risk of threats to external validity in the sample conditions for studying the population as designated in the research design. I have elected to use data directly associated with Mercedes-Benz associates after MBPS implementation.

Internal Validity

The concept of internal validity for this research study was relevant to the effort of examining cause and effect after the implementation of the MBPS. The causal impact of the independent variables on the dependent variable was relevant in this research study. The research effort involved a quantitative comparable investigation of the effects of the independent variables cycle-time variation, employee-headcount variation, and KPIs on the dependent variable, productivity.

Internal validity was important in social science research studies and affected by different factors. Cook and Campbell (1979) defined factors that affect internal validity as historical environmental events, mortality from lost test subjects, learning research instruments from pretests and posttests, issues related to statistical regression, and issues that arise from testing when test subjects become test-wise. Internal validity was viewed as scientific research that depends on the causal impact of the outcome, the effects of this causal impact could cause limitations (Cook & Campbell, 1979). Internal validity refers to a causal comparison that exists between independent and dependent variables. Therefore, inferences consist of a few factors that determine the characteristics of internal validity. Causal inference was present when chronological precedence, covariation, and nonspuriousness are present (Cook & Campbell, 1979). Researchers recognize chronological precedence when the cause in research precedes the effect by effect being identified first, covariation exists when a relative link exists between the cause and the effect in a research study, and nonspuriousness occurs when there are not any plausible alternate explanations in a research study and researchers eliminate probable cause of another option (Cook & Campbell, 1979). Researchers commonly manipulate independent variables and study the effects to the dependent variable. Researcher should establish confidence through observations that a study has achieved a clear differentiation in the dependent variable and was affected by causal impact from the independent variables (Cook & Campbell, 1979). After ensuring the elimination of other potential explanations, researchers can consider the causal inference to have achieved internal validity (Cook & Campbell, 1979). I dealt directly with the threat to internal validity by recognizing that a potential impact exists through the independent cycle-time variation, employee-headcount variation, and KPIs and how they influence the dependent variable, productivity. I identified potential internal validity and perform an indeterminate research study irrespective of any associations established among the independent and dependent variables.

Construct Validity

I adopted the survey questions for this study from previously published research (Opara, 1995; Stout, 2014). Opara (1995) and Stout (2014) scientifically constructed and fundamentally developed the research instrument. The survey questions ensured I achieve psychometric properties as intended. Empirical information assessments are necessary to ensure the measurements are sufficient and require three components: unidimensionality, reliability, and validity (O’Leary-Kelly & Vokurka, 1998). Researchers usually use unidimensionality to identify items and test scores in publications (O’Leary-Kelly & Vokurka, 1998). The framework of unidimensionality constructs includes indicators designed to align with only one construct (Ziegler & Hagemann, 2015). The concept of unidimensionality relates to the logical and empirical requirement that a variable must be unidimensional (Ziegler & Hagemann, 2015).

Construct validity distinctively relates to the suitability of inferences prepared within the framework of observational or measurement quantities and ensures the achievement of the intended research construct. Construct validity was an important concept for research studies where researchers collect and measure data from observations performed and was another possible research limitation. Researchers feel that experimental design development and the formalization of hypotheses are problematic and misguided by threats to construct validity (Ziegler & Hagemann, 2015). Threats to the impact of construct validity include guessing in hypotheses, experimental design bias, confounding narrow predicted outcomes, and expectations of a researcher. Guessing in hypotheses occurs when research subjects know or guess the study's result, experimental design bias can be intentional or unintentional and was present when bias exists in the design process, confounding narrow predicted outcomes are present when variables that are outside the scope for the project affect the root cause, and issues regarding expectations of the researcher are present when unintentional miscommunication of expectations occurs (Ziegler & Hagemann, 2015).

Construct validity relates to testing specifications and the research instrument measurements are normally parallel with the theoretical framework related to the research study (Frankfort-Nachmias & Nachmias, 2008). I grounded this research study on the modeled success observed through research ideas of the TPS theory and clearly explain the MBPS philosophies. This research study involved an attempt to develop and formulate information created through many years of research in the global automobile manufacturing industry.

This research included published research instruments tested and used in other research studies (Opara, 1995; Stout, 2014). Researchers have systematically developed and fundamentally proven the research instrument. The survey questions chosen was the guide for ensuring I achieve the psychometric requirements as planned (Churchill, 1979).

The expectant results included information from the research study that confirmed that the data collected are sufficient.

Ethical Procedures

This research study included a research instrument, and I submitted it for approval by the Walden University IRB. The Walden IRB approval number for my study is 06-12-17-0042772. The ethical significance in this research effort includes data collection. Data collection efforts posed a risk when they included human subjects. The proposed study was nonexperimental research, and I did not anticipate any direct data collection issues from human research subjects. Researchers are responsible for abiding by ethical standards to ensure research subjects agree to complete survey questionnaires and all respondents in the research study consent to participate. Researchers must clearly ask respondents not to expose their names in questionnaires, and surveys must ensure there was strict confidentiality and anonymity in the data collection procedures. I created an executive summary available to the respondents freely upon request.

The IRB evaluated this research study for project information, a general description of the proposed work, community research stakeholders and partners, potential risk and benefits, data integrity and confidentiality, and potential conflicts of interest. Stakeholders for this research effort was employees who work in the MBPS and Mercedes-Benz cars. These employees and the company represented inputs of the independent variables and outputs of the dependent variable. Organizational leaders proposed efforts to implement quality production systems that aim to refine and improve processes through lean methodologies.

Researchers must understand the importance of ethical issues when studies include human participants (Mitchell & Wellings, 2013). As a step to understand and qualify the ethical process, I completed the certification course through the National Institutes of Health (NIH), which was an organization that protects the individual rights, dignity, and privacy of all human research participants while undergoing and participating in research studies. Researchers should disclose all aspects and intentions of a research study to likely research participants (Mitchell & Wellings, 2013). Wisdom, Cavaleri, Onwuegbuzie, and Green (2012) indicated that it was important that researchers ensure the disclosure of all aspects and intentions of research studies with participants. Researchers should also understand and be aware when conducting online surveys that human research subjects are also called human participants, and they must receive full disclosure of all aspects of the study (Mitchell & Wellings, 2013). In the introduction of the survey instrument, this research study included an informed consent letter that expressed the details and cautionary measures in the study that ensured the execution of ethical procedures throughout the study. Informed consent was in the introduction of the online survey and alerts research participants that continuing through to the information screen established acceptance of informed consent.

This research study took all cautionary actions to ensure that participate privacy was protected and research bias not present. The plan to achieve participate privacy and bias control consisted of the following: applying unique identifiers to each participant so that individual names and personal information are not exposed during the research study, applying unique identifiers as labels for identifying participant data, and also using unique identifiers to reference participants in the research study results (Wisdom et al., 2012). Even though protective measures are in place, researchers must understand that inherent risks still exist in their research study, as they do in all research studies. During the course of this research study, I remained aware of the importance of mitigating the risk of potential harm and ethical infringement to the participants. I procured informed consent for the following participant protections: right to privacy, confidentiality, and ensuring integrity of all precautions (Tong et al., 2014; Wagner & Esbensen, 2015). It was expected and important that confidentiality and protection was in place to protect the names of research survey participants, company managers, and the companies discussed in the research study (Mitchell & Wellings, 2013). This research study involved all moral and relevant measures to ensure the privacy of the individuals involved. If research participants have comments, questions, or concerns regarding this research study, I provided my points of contact in the online survey instrument. The only time that a survey participant has direct contact with me was if the participant contacts me. Participation in this research effort did not include any incentives.

Summary

The purpose of this comparative research study was to determine the impact and influences to the productivity at Mercedes-Benz cars between 1999 and 2017, following implementation of the MBPS in 1999. The quantitative method involved surveys sent to participants who are employees who worked for the company between 1999 and 2017. The aim of this research study was to evaluate the development of the TPS as a model to reference for implementing the methodology in MBPS. The evolution of the TPS experienced several challenges during the developmental phases. The methodology suffered negative effects from multiple actions that occurred during the 1950s, including a labor crisis, labor force flux, overproduction issues, and large quantities of worker variation (Lai et al., 2014). Threats by recessional influences negatively impacted financial markets and the pressure affected Toyota. The global impact in the automotive markets led to actions of bankruptcy potentials and fluctuation in employee headcount. In addition to the improvements made during the design and formalization of TPS, Toyota also experienced challenges in understanding the improved production system (Lai et al., 2014). The rigor in the methods developed by Toyota's management group supported the decision made by leaders of Mercedes-Benz cars to model TPS. Achievements in the areas of product research, new product expansion, and production system implementation are the unique approaches that defined Toyota's success (Lai et al., 2014).

Toyota's fortitude and continuous efforts to perfect its production system implementation and improvements of U.S. management methodologies developed from the framework of scientific management (Lai et al., 2014). The strength of Toyota's formalization efforts had roots in knowledge produced by W. Edwards Deming's lectures on problems in quality control and efficiency in Japanese manufacturing processes (Lai et al., 2014). Lessons learned from Toyota confirmed to leaders at Mercedes-Benz cars that modeling the TPS process of implementing quality control methods, statistical process limits, quality controls, and Shewhart's control charts were all contributors to Toyota's success and this condition allowed information sharing throughout the organization (Lai et al., 2014). The production system development also ensured that all levels of the organization received training, including first-line supervisors, associates, and professional employees. Mercedes-Benz cars benefited from Toyota’s formalization efforts in empowering the workforce on statistical quality control tools, data communication, information on the shop floor, and continuous process improvement (Ham & Park, 2014; J. Li, 2013). This research study involved investigating whether productivity in Mercedes-Benz cars depends on the independent variables cycle-time variations and headcount variation. In this chapter, I explained the research efforts planned to answer the research questions.

Chapter 4 includes an explanation of the results of the analysis of the study.

Chapter 4: Results

Introduction

The purpose of this quantitative study was to explore the effects of cycle-time variation, employee-headcount variation, and KPIs on employee productivity using the MBPS. Survey data were gathered from 35 employees of Mercedes-Benz cars.

Table 2 displays the frequency counts for the demographic variables in the study. Table 3 provides the psychometric descriptive statistics for the scale scores productivity, cycle-time variation, employee headcount variation, and KPIs. Table 4 displays the nonparametric Spearman correlations among the scale scores to answer the research questions. As additional findings, Table 5 and Table 6 provided the nonparametric Spearman correlations for the scale scores with the demographic variables.

Data Collection Process

In compliance with Walden University research policy, I met the IRB guidelines before collecting any data using Survey Monkey. Before beginning the survey, all participants signed a statement of consent for participation. The consent included the purpose, procedures, and potential benefits of the study and made clear that the information was anonymous. Signing indicated that the candidates understood that participation was voluntary. I made certain that candidates knew they could withdraw from the study at any time.

Information displayed by Data from SurveyMonkey showed only the results and excluded research participants’ identities anonymous. This study used survey questions to answer questions about KPIs in the MBPS that affected productivity from 1999 to 2017.

This data collection effort sought information from operation's managers, plant managers, manufacturing engineers, and shop-floor workers. This target group provided the most valuable responses based on their daily involvement in manufacturing activities related to elements such as cycle time and employee headcount.

Results of Study

Descriptive Statistics

Table 2 provides the frequency counts for the demographic variables in the study. Current position for the employees was mostly split between technician/assembler (45.7%) and engineer/support (40.0%), with five additional supervisor/managers (14.3%). There were 20 male (57.1%) and 15 female employees (42.9%). Ages ranged from 25-55 years (*M* = 39.00, *SD* = 8.00). Years worked for Mercedes-Benz cars ranged from 3-21 years (*M* = 9.37, *SD* = 5.02) (Table 2).

Table 2

*Frequency Counts for Selected Variables (*N *= 35)*

Variable	Category	*n*	%
Current position			
	Technician or assembler	16	45.7
	Engineer or support	14	40.0
	Supervisor/manager	5	14.3
Gender			
	Male	20	57.1
	Female	15	42.9
Age [a]			
	25-30	5	14.3

	30-39	14	40.0
	40-49	12	34.3
	50-55	4	11.4
Years worked for Mercedes Benz Cars [b]			
	3-5	10	28.6
	6-10	12	34.3
	11-14	6	17.1
	15-21	7	20.0

[a] *M* = 39.00 years, *SD* = 8.00.

[b] *M* = 9.37 years, *SD* = 5.02.

Table 3 displays the psychometric characteristics for the four scale scores (productivity, cycle-time variation, employee headcount variation, and KPIs). The four Cronbach alpha reliability coefficients were all α > .80. This suggested that all scales had adequate levels of internal reliability (Cronbach, 1951; Diedenhofen, & Musch, 2016) (Table 3).

Table 3

Psychometric Characteristics for the Summated Scale Scores (N = 35)

Score	Number of Items	*M*	*SD*	Low	High	α
Productivity	10	2.75	0.94	1.00	5.00	.83
Cycle-time variation	10	2.49	1.19	1.00	5.00	.91
Employee headcount variation	10	2.87	1.03	1.00	5.00	.83
KPIs	6	3.28	1.40	1.00	5.00	.92

Research Questions

Research Question 1 asked, How does the variation in cycle time affect the productivity of Mercedes-Benz cars? and the related null hypothesis predicted H_0: Variation in cycle time does not affect the productivity of the Mercedes-Benz Car Company. To answer this, Table 4 provides the nonparametric Spearman correlations for cycle-time variation with productivity. Spearman correlations were used instead of the more common Pearson correlations due to the low sample size ($N = 35$). In addition, due to the low sample size and the exploratory nature of the study, findings significant at the $p = .10$ level were noted to suggest possible avenues for future research. Although there was a trend for higher scores for cycle-time variation with higher scores for productivity ($r_s = .28$, $p = .10$), the results did not reach significance at the $p < .05$ level. This provided no support to reject the null hypothesis (Table 4).

Research Question 2 asked, How does the variation in the number of employees affect productivity in the MBPS between 1999 and 2017? and the related null hypothesis predicted H_0: Variation in the number of workers does not affect the productivity of the MBPS between 1999 and 2017. To answer this, Table 4 displays the nonparametric Spearman correlations for employee headcount variation with productivity. Inspection of the table found no significant correlation for employee headcount variation and productivity ($r_s = .02$, $p = .93$). This provided no support to reject the null hypothesis (Table 4).

Research Question three asked, What are the KPIs (KPIs) in the MBPS that affected productivity between 1999 and 2017 and the related null hypothesis predicted H_0: KPIs does not affect the productivity of the MBPS between 1999 and 2017. To answer this, Table 4 provides the nonparametric Spearman correlations for KPIs with productivity. KPIs were not related to productivity ($r_s = .20$, $p = .26$). This provided no support to reject the null hypothesis (Table 4).

Table 4

*Spearman Correlations among the Summated Scale Scores (*N = 35*)*

Score	1		2		3	4
1. Productivity	1.00					
2. Cycle-time variation	.28	*	1.00			
3. Employee headcount variation	.02		.32	*	1.00	
4. KPIs	.20		.08		.11	1.00

* $p < .10$. ** $p < .05$.

Additional Findings

Table 5 displays the nonparametric Spearman correlations for productivity, cycle-time variation, employee headcounts variation, and KPIs with current position and gender. Position had a positive correlation with KPIs ($r_s = .51$, $p = .002$). Gender of the respondent was not significantly correlated with any of the four scale scores (Table 5).

Table 5

*Spearman Correlations for Scale Scores with Position and Gender (*N = 35*)*

Variable	Position [a]	Gender [b]

Productivity	.24	-.20
Cycle-time variation	-.07	-.15
Employee headcount variation	.08	-.16
KPIs	.51 ***	-.23

* $p < .10$. ** $p < .05$. *** $p < .01$. **** $p < .005$.
[a] Position: 1 = *Technician or Assembler*, 2 = *Engineer or Support*, 3 = *Supervisor or Manager*
[b] Gender: 1 = *Male*, 2 = *Female*

Table 6 provides the nonparametric Spearman correlations for productivity, cycle-time variation, employee headcounts variation, and KPIs with age and years worked for Mercedes-Benz cars. Neither age nor years worked were significantly correlated with any of the four scale scores (Table 6).

Table 6

*Spearman Correlations for Scale Scores with Age and Years Worked for Mercedes-Benz cars (*N *= 35)*

Variable	Age	Years Worked
Productivity	.01	-.13
Cycle-time variation	.01	-.17
Employee Headcount Variation	-.08	-.08
KPIs	.01	-.01

* $p < .10$.

Summary

In summary, this study used survey responses from 35 employees of Mercedes-Benz cars to explore the effects of cycle-time variation, employee-headcount variation, and KPIs on employee productivity using the Mercedes-Benz Production System. Hypothesis 1 (productivity and cycle time) was not supported (Table 4). Hypothesis 2 (productivity and headcount) was not supported (Table 4). Hypothesis 3 (productivity and KPIs) was not supported (Table 4).

In the Chapter 5, these findings were compared to the literature, conclusions and implications was drawn, and a series of recommendations were suggested. Base on my research study the examples of TPS was successful in automobile manufacturing and presented positive results for Toyota car manufacturing. However, the statistical data from my research study was not able to prove that Mercedes-Benz cars effort to model TPS through MBPS achieved the same level of success.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this quantitative, comparative study was to determine whether implementing MBPS positively or negatively affected the productivity of Mercedes-Benz cars between 1999 and 2017. This study investigated the potential relationship between the variables of cycle-time variation, employee-headcount variation, KPIs and productivity based on a survey of current Mercedes-Benz cars employees. The evaluation of Mercedes-Benz cars' productivity included an investigation of three independent variables: cycle-time variation, employee-headcount variation, and KPIs. The MBPS productivity was the dependent variable in this research study. Chapter 5 includes a discussion of the interpretations of the findings, the study limitations, recommendations for future research, and implications for the MBPS effects of positive change on the automotive industry.

Chapter 3 include discussions of the operationalization of variables and the background of establishing the survey instrument. The research instrument executed was a survey based on three research questions with three hypotheses and sent to a selected population. The survey population of Mercedes-Benz cars employees worked directly in the Mercedes-Benz car manufacturing plant in the United States. The research population consisted of following positions: operation managers, plant managers, manufacturing engineers, and shop workers. The study concluded with 35 respondents completing the survey. The research questions were as follows:

1. How does the variation in cycle time affect the productivity of Mercedes-Benz cars?
2. How does the variation in the number of employees affect productivity in the MBPS between 1999 and 2017?
3. What are the KPIs in the MBPS that affected productivity between 1999 and 2017?

Chapter 5 of this study includes the interpretation of the findings from the research questions, which indicates whether the data supported the hypotheses established in the investigation.

Interpretation of the Findings

The participants in the study were current Mercedes-Benz cars employees (N = 35, 20 males and 15 females) located in the United States. They held diverse job titles: 16 were technicians or assemblers, 14 were engineers or production support, and 5 were supervisors or managers. The ages of the participants ranged from 25 to 55. The number of years the survey respondents worked for Mercedes-Benz cars ranged from 3 to 21, with an average of 9.37 years.

To support or reject the research questions' hypotheses, the study included a confidence level of 90% and $p < .10$. Based on the sample size of 35, I used Spearman's correlations to determine the research study's confidence level, which denoted a 90% chance that the hypothesis were accurate and a 10% chance it was not. Given the study's low sample size, it was not possible to reach significance at a 95% confidence level, with $p < .05$.

The focus of the analysis of the findings was on reliability, which involved using Cronbach's alpha, the application that verifies the observed link as evidence of the items underlying the scores for each variable. Assessing the reliability measures involved conducting a principal component analysis before applying Cronbach's alpha. All reliability statistics received test-for-respondent level well-being and activity level based on the psychometric characteristics scale scores for each variable in this study measured above $\alpha > .70$. The research study was reliable, measuring $\alpha > .83$ for productivity, $\alpha > .91$ for cycle-time variation, $\alpha > .83$ for employee headcount variation, and $\alpha > .92$ for KPIs.

Calculating the Spearman correlation involved comparing the scale scores of cycle-time variation, employee-headcount variation, and KPIs against position and gender with the survey respondents examining significance. One significant comparison emerged between higher position levels and KPIs during the study regarding scale scores to position and gender. More senior-level positions such as engineering or support and manager or supervisor roles produced significance and had more information about KPIs. The correlation between KPIs and higher positions was significant because this group was usually responsible for controlling and trending data. The research study data supported higher level positions that showed more interest regarding KPIs.

Research Question 1: How does the variation in cycle time affect the productivity of Mercedes-Benz cars?

$H1_0$: Variation in cycle time does not affect the productivity of the Mercedes-Benz Car Company.

$H1_a$: Variation in cycle time does affect the productivity of the Mercedes-Benz Car Company.

To address Research Question 1, the analysis involved testing the null hypothesis were tested using Spearman's correlation. The result of the data analysis showed $r_s = .28$, $p = .10$, which indicated that a relationship existed for the cycle-time variation related to productivity at the $p = .10$ level. The results of this research study did not reach significance at the $p < .05$ level; therefore, the results did not provide substantial support to reject the null hypothesis. The conclusion indicated there was a 90% chance that the finding was correct for cycle-time variation being significant to productivity and a 10% chance it was not correct.

Research Question 2: How does the variation in the number of employees affect productivity in the MBPS between 1999 and 2017?

$H2_0$: Variation in the number of workers does not affect the productivity of the MBPS between 1999 and 2017.

$H2_a$: Variation in the number of employees does affect the productivity of the MBPS between 1999 and 2017.

To address Research Question 2, the analysis involved testing the null hypothesis using Spearman's correlation. The result of the data analysis showed $r_s = .02$, $p = .93$, which indicated that there was no relationship correlation for employee headcount variation and productivity. Therefore, the results did not provide substantial support to reject the null hypothesis.

Research Question 3: What are the KPIs in the MBPS that affected productivity between 1999 and 2017?

$H3_0$: KPIs did not affect productivity in the MBPS between 1999 and 2017.

$H3_a$: KPIs did affect the productivity of the MBPS between 1999 and 2017.

To address Research Question 3, the analysis involved testing the null hypothesis using Spearman's correlation. The result of the data analysis showed $r_s = .20$, $p = .26$, which indicated KPIs did not have any relationship to productivity. Therefore, the results did not provide substantial support to reject the null hypothesis.

During hypotheses testing, the variables of cycle-time variation, employee-headcount variation, and KPIs underwent testing for significance using Spearman correlations among the summated scale scores. One relationship emerged during hypotheses testing. A proportional relationship existed between cycle-time variation and productivity, which meant that when cycle-time variation measured higher, productivity also measured higher. For cycle-time variation the result of the data analysis showed $r_s = .28$ and $p < .10$ level. This MBPS research study aligns with Powell et al.'s (2013) study, as they noted that productivity and cycle-time variation are important in maintaining an efficient production system. Powell et al. also defined TPS as a quality production system that was well organized and operates effectively without as many resources but with a focus on cycle time, inventory, space, labor, and capital expenditures. Kumar and Kumar (2014) also expressed support with the significance of cycle-time variation as a practical option for organizational leadership while working to improve efficiency, productivity, and cost to support customer interest. Cycle time was a primary performance measure for quality production systems to operate effectively (Godinho Filho & Uzsoy, 2014). Cycle time improvements in production systems received credit for creating positive results in productivity by decreasing work in progress (WIP), operating capital for operation, assisting leaders in the automotive industry adjust to market changes with ease, and increasing production output (Godinho Filho & Uzsoy, 2014). Hsieh et al. (2014) noted that increasing WIP has a high probability of producing adverse effects to cycle time on production systems. Ţenescu and Teodorescu (2014) indicated that organizational leadership should be conscious of production system advancements in automotive manufacturing to improve cycle time continuously. Ţenescu and Teodorescu also indicated that reduction in cycle time was essential in a reduction of product development cycle times, process sustainability, and quality output to sustain a competitive response in the industry. Saraswat et al. (2015) researched successful production systems and noted that reduced cycle times in product manufacturing positively affect productivity.

There was a direct relationship between employee headcount variation and cycle-time variation, which meant when employee headcount variation measured higher in response, then cycle-time variation also measured higher. For employee headcount variation the result of the data analysis showed $r_s = .32$ and $p < .10$ level. The comparative relationship identified between employee headcount variation and cycle-time variation during hypotheses testing supported key findings discussed in the literature review. Langdon and Lehrman (2012) noted an increase in manufacturing employer expenses has a direct effect on employee variability and MBPS cycle-time variation. The findings agreed with the statement that if company leaders do not properly implement lean-manufacturing systems and methodologies, there was a direct effect on employee headcount variability to meet customer demand (Langdon & Lehrman, 2012). Hicks (2013) indicated that adding to employee headcount to achieve customer demand directly affects the cycle time and was not healthy for productivity percentages. The relationship between employee headcount variation and cycle-time variation responds positively or negatively depending on the success of implementing lean tools and methods. The success of implementing lean tools and methods also controls cost advantages and disadvantages on companies' employee headcount variability and cycle time variability (Hicks, 2013). The efforts by Toyota leaders to develop the process to improve productivity gained support in work by Mercedes-Benz cars through MBPS implementation to maximize existing resources. The MBPS exhibited elements of Taylorism's standardized work design through production flow, production pace (heijunka), and implementing tools that reduced production inefficiencies (Iuga & Kifor, 2013). In addition, MBPS leaders perfected the production system to concentrate on continuous improvement, which created a positive effect on productivity that supports the data produced by employee headcount variation and cycle-time variation (Rutledge & Martin, 2016). Furthermore, MBPS presents the concepts of CIP by improving productivity and increasing employee morale and production layouts on the structure process assembly (Jayamaha et al., 2014). Through the implementation of CIP, the employees of Mercedes-Benz cars improved the assembly process increasingly by answering challenges in the process. This research study supports the MBPS process improvements through social change, production efficiency, skill development and affirming the importance to use kaizen principles (Jayamaha et al., 2014). Traditionally, lean production principles influenced Mercedes-Benz cars and leaders did not consider this methodology as effective, which resulted in using the TPS concept of CIP (Khan et al., 2013). In contrast, MBPS improved process waste, product development, and the effect on productivity within the process as identified from TPS (Khan et al., 2013). Henceforward using the TPS concept of CIP as an undisrupted cycle that focuses the Mercedes-Benz cars employees on increasing productivity and eliminating the cost associated in the manufacturing process (Haider & Mirza, 2015).

Limitations of the Study

Limitations in the study of MBPS led to constraints during the data collection phase of the research study. The manufacture of Mercedes-Benz cars occurs in one location in the United States and posed limitations on the time allotted to locate survey participants and facilitate research questionnaires. I elected to facilitate research questionnaires through social media and SurveyMonkey audience global panel and it was difficult finding survey participants to fulfill 100 completed surveys. Regardless of whether the sample goal was large or small, finding an audience of anonymous survey participants who were current employees of Mercedes-Benz cars was a challenge. I targeted a population of Mercedes-Benz cars employees who were operation managers, plant managers, manufacturing engineers, and shop-floor workers who worked in the MBPS between 1999 and 2017.

The chosen group of survey participants met the conditions of participation by having experienced daily work and activities related to productivity, cycle time, and employee headcount. Even though this group of participants covered positions ranging from shop-floor workers to decision makers in the company, they all had direct experience with MBPS. The participants identified had practical experience with MBPS and covered a gap of time that would add knowledge to the evolution of the production system. These identifiers were part of the survey instrument study; however, only 35 participants provided completed surveys out of 100 surveys attempted. Due to the lack of available survey participants during the data collection phase of the study, the number of completed surveys was lower than expected. A broader participant audience involving other Mercedes-Benz divisions based on the production systems used across the organization would have produced more insight into the company. This research study includes data that represent only one division of the Mercedes-Benz automotive organization: Mercedes-Benz cars. Therefore, the research results are not generalizable across all Mercedes-Benz manufacturing plants.

Recommendations

The results of this research study showed that individuals who participated in the survey indicated that the MBPS was valid when examining cycle-time variation relative to productivity. These individuals also expressed that cycle-time variation was relative to employee headcount variation. The results of the study did not provide support to reject the null hypotheses for the research questions. I assume, if the study is expanded to a larger audience of survey participants who can speak on the effect of the MBPS on productivity could enhance the study further. The study could also include other independent variables that would strengthen the research effort, including continuous improvement, production changeover time, WIP, production capacity variation, equipment downtime, and in-process defect data. These topics are recommendations for further research that would help close the gap on how productivity impact in MBPS. Results of the study could help Mercedes-Benz organizational leadership direct their business planning and capital expenditure toward essential projects associated with optimizing and standardizing the production systems company-wide.

The specific design of this research study was to investigate the causal effect on the dependent variable of productivity at Mercedes-Benz cars using the independent variables of cycle-time variation, employee-headcount variation, and KPIs between 1999 and 2017. Productivity, cycle-time variation, and employee headcount variation are key performance metrics when performing a research study on the value of production systems (Godinho Filho & Uzsoy, 2014). Research limitations and disadvantages occur while using survey instruments in explanatory research. Kerzner (2004) noted that researchers who use survey instruments in explanatory research studies face disadvantages with the data collected. However, researchers can easily identify and infer the connection between research variables with a survey instrument. It was difficult to establish causality in the relationship between variables in research studies when using survey instruments versus conducting experimental research studies (Kerzner, 2004). The research question of the value of causal impact between the relationship of variables selected in this study was accurate or not requires additional research.

This research study was the first step in the process toward understanding the Mercedes-Benz cars organization and what variables, KPIs, and factors affect productivity in the MBPS. This research study was also a step in the process to understanding what variables to consider in a future causal analysis in the MBPS. A causality research study on the different variables and measures in the MBPS may reveal more cause and effect findings on the impact of the effectiveness of MBPS in the Mercedes-Benz organization. Future researchers who study the MBPS may want to replicate this study to explore various relationships among the population of individuals with experience working in the production system. For example, researchers may want to investigate what findings was different across various demographic work positions and variables. As previously discussed, more research was necessary on the relationship between various independent variables and productivity as the dependent variable to discover the effect of MBPS. This research study provides a foundation to understand MBPS; however, more extensive research was necessary on this subject with adjustments to the research instruments to address each independent variable.

Lastly, there was a level of subjectivity in the participant responses to the survey questionnaire, which could reflect a knowledge gap in the accuracy of information linked to the study results being successful or not based on job-related responses. In addition, the population of the study did not include every position in the company due to the assumed value by job-related responses. By not including more job-related responses to the research study could have caused limitations that introduced a margin of error in coverage in the sampling framework.

Implications for Social Change

Mercedes-Benz cars and the automotive industry continue to evolve relative to advances in technology and quality production system implementations, MBPS was important and affects positive social change. The information learned from this research study may affects positive social change by providing engineers, manufacturing managers, shop-floor workers, and Mercedes-Benz leadership with critical information needed to make more objective decisions in MBPS. The research study has practical implications for Mercedes-Benz cars employees and stakeholders interested in supporting proper implementation of production systems to improve productivity in MBPS. The findings of this research study showed that productivity was significant and positively correlated with cycle-time variation. Based on the sample size of 35, no correlated relationship existed between headcount variation and productivity. The research study also showed that no correlated relationship existed between KPIs and productivity.

The information presented in the current research study contributes to the field of engineering management and lean manufacturing by providing automotive manufacturing industry engineers, manufacturing managers, shop floor workers, and Mercedes-Benz leadership knowledge and awareness of research on implementing production systems. Mercedes-Benz leadership, automotive manufacturing leaders, and workers may use the results of this study to understand the perspectives of employees in the automotive manufacturing field. Therefore, this research study may serve to empower Mercedes-Benz leadership, automotive manufacturing leaders, and workers to influence the need to implement effective production systems properly.

Conclusion

This study adds to the body of knowledge in expanding the MBPS, automotive manufacturing field, lean manufacturing, and engineering management. This research study may provide future researchers information that they may find useful, such as the relationships among the MBPS variables of headcount variation and cycle-time variation to productivity at Mercedes-Benz cars. Researchers in the field of engineering management who are investigating production system implementation, MBPS, TPS, and productivity outcomes are beneficiaries of this study and benefits with a foundation on how to examine the causal impact of implementing production systems. The research problem led to examining how MBPS implementation affects productivity; this research provides may help people working in the field of engineering management to gain an understanding of the effectiveness of the production system's implementation.

Among the participants working in the field of engineering management and the automotive industry, a statistically significant positive correlation existed for the cycle-time variation related to productivity. Although the trend resulted in higher scores for cycle-time variation with productivity scores at the .10 level, the outcomes did not measure significant at the $p < .05$ level. Therefore, the results did not provide support to reject the null hypothesis. No statistically significant correlation existed between employee headcount variation and productivity, and the results did not measure strong enough to support rejecting the null hypothesis. Results for KPIs did not support a relationship with productivity. The outcomes did not support rejecting the null hypothesis. Further research will be necessary to improve the confidence of the study.

The premise of this quantitative comparative study was to investigate the cause and effect relationship of the productivity performance to cycle-time variation and headcount variation at Mercedes-Benz cars after implementing the MBPS. The MBPS provides the positive social impact needed to assist automotive manufacturing companies and production system leadership in understanding the effective implementations of production systems. Better implementations help improve production systems by removing issues such as defects in product manufacturing, missing production requirements, and employee disengagement in automobile manufacturing companies. When implemented properly, manufacturing production systems can have a positive effect on productivity, process waste, cycle time, and performance (Bagozzi, 2012). The focus of the study was primarily on the MBPS implemented by exhibiting philosophies of TPS**.**

The basis of my research in the literature review shows that TPS was effective in the automobile manufacturing industry for Toyota Car Company. However, the results from my research study did not prove that Mercedes-Benz cars exhibited the same level of success by implementing the TPS model through MBPS. The positive social change aspect in my research study intended to eliminate ergonomic risk, safety issues, and negative economic conditions through implementing MBPS. Therefore, future research into this area should include a restatement of research questions, an expansion of survey participants and the inclusion of other Mercedes-Benz automobile divisions in the study. The social change implications for this research may promote positive social change by its emphasis on the implementation of manufacturing production systems. Such implementations may then stimulate increased economic efficiencies, quality, and profitability for society.

References

Ali, R., & Deif, A. (2014). Dynamic lean assessment for takt time implementation. *Procedia CIRP, 17,* 577–581. doi:10.1016/j.procir.2014.01.128

Alma, O. G., Kurt, S., & Ugur, A. (2011). Genetic algorithms for outlier detection in multiple regression with different information criteria. *Journal of Statistical Computation and Simulation, 81*, 29–47. doi:10.1080/00949650903136782

Amasaka, K. (2014). “New JIT”: A new management technology principle at Toyota. *Journal of Advanced Manufacturing Systems, 13,* 197–222. doi:10.1142/S0219686714500127

Anderson, H. J., Tathum, R., & Black, W. (1998). *Multivariate data analysis* (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Bagozzi, P. R. (1980). Performance and satisfaction in an industrial sales force: An examination of their antecedents and simultaneity. *Journal of Marketing*, *44*(2), 65–77. doi:10.2307/1249978

Bagozzi, P. R., Yi, Y., & Phillips, L. W. (1991). Assessing construct validity in organizational research. *Administrative Science Quarterly, 36,* 421–458. doi:10.2307/2393203

Baldos, U. C., & Hertel, T. W. (2014). Global food security in 2050: the role of agricultural productivity and climate change. *Australian Journal of Agricultural & Resource Economics,* 58(4), 554-570. doi:10.1111/1467-8489.12048

Begam, M. S., Swamynathan, R., & Sekkizhar, J. (2013). Current trends on lean management—A review. *International Journal of Lean Thinking*, *2*(4), 15–21. Retrieved from http://thinkinglean.com/

Berawi, M. A. (2015). Technology breakthrough: A need for continuous improvement. *International Journal of Technology*, *6*, 302–305. doi:10.14716/ijtech.v6i3.1507

Chiarini, A., & Vagnoni, E. (2015). World-class manufacturing by Fiat. Comparison with Toyota Production System from a strategic management, management accounting, operations management and performance measurement dimension. *International Journal of Production Research*, 2, 590-606. doi:10.1080/00207543.2014.958596

Chowdhury, S. D. (2014). Strategic roads that diverge or converge: GM and Toyota in the battle for the top. *Business Horizons*, 1, 127-136. doi:10.1016/j.bushor.2013.10.004

Choy, L. (2014). The strengths and weaknesses of research methodology: Comparison and complimentary between qualitative and quantitative approaches. *IOSR Journal of Humanities and Social Science*, *4*(19), 99–104. doi:10.9790/0837-194399104

Choy, L., Mokuau, N., Braun, K., & Browne, C. (2008). Integration of cultural concepts in establishing Ha Kupuna: The National Resource Center for Native Hawaiian Elders. *Journal of Native Aging & Health, 3*, 5–12. Retrieved from http://www.asaging.org

Churchill, G. A. (1979). A paradigm for developing better measures of marketing construct. *Journal of Marketing Research, 16,* 64–73. doi:10.2307/3150876

Ciemnoczolowski, D. D., & Bozer, Y. A. (2013). Performance evaluation of small-batch container delivery systems used in lean manufacturing—Part 2: Number of Kanban and workstation starvation. *International Journal of Production Research, 51,* 568–581. doi:10.1080/00207543.2012.656331

Cimini, M. H., & Muhl, C. J. (1994). UAW and NUMMI avoid strike. *Monthly Labor Review, 117*(11), 64. Retrieved from http://www.bls.gov/mlr/

Clarke, C. (2005). *Automotive production systems and standardisation: From Ford to the case of Mercedes-Benz.* Heidelberg, Germany: Physica-Verlag.

Cohen, A. (2003). *multiple commitments in the workplace.* Mahwah, NJ: Lawrence Erlbaum Associates.

Concas, G., Lunesu, M. I., Marchesi, M., & Zhang, H. (2013). Simulation of software maintenance process, with and without a work-in-process limit. *Journal of Software: Evolution and Process, 25,* 1225–1383. doi:10.1002/smr.1599

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design and analysis issues for field settings*. Boston, MA: Houghton Mifflin.

Cooper, R. G., Edgett, S., & Kleinschmidt, E. (1998). *Portfolio management for new products.* Cambridge, MA: Perseus Books Group.

Cronbach, L. J. (1951). *Coefficient alpha and the internal structure of tests. Psychometrika,* 16, 297–334. doi: 10.1007/BF02310555

Cronbach, L. J. (1971). Test validation. In R. L. Thorndike (Ed.), *Educational measurement* (2nd ed., pp. 443–507). Washington, DC: American Council on Education.

Dahlgaard, J. J. (2014). From organisational assessment and continuous improvement to learnability, innovability and sustainability. *Total Quality Management & Business Excellence, 25,* 967–968. doi:10.1080/14783363.2014.954444

Dattalo, P. (2008). *Determining sample size: Balancing power, precision, and practicality*. New York, NY: Oxford University Press.

Diedenhofen, B., & Musch, J. (2016). Cocron: A web interface and R package for the statistical comparison of Cronbach's Alpha coefficients. *International Journal of Internet Science*, *11*(1), 51-60.

Faccio, M. (2014). The impact of production mix variations and models varieties on the parts-feeding policy selection in a JIT assembly system. *International Journal of Advanced Manufacturing Technology, 72,* 543–560. doi:10.1007/s00170-014-5675-0

Faccio, M., Gamberi, A., & Persona, A. (2013). Kanban number optimisation in a supermarket warehouse feeding a mixed-method assembly system. *International Journal of Production Research, 51,* 2997–3017. doi:10.1080/00207543.2012.751516

Feldman, M. S., & Pendland, B. (2003). Reconceptualizing organizational routines as a source of flexibility and change. *Administrative Science Quarterly, 48,* 94–118. http://dx.doi.org/10.2307/3556620

Follmann, J., Laack, S., Schütt, H., & Uhl, A. (2012). Lean transformation at Mercedes-Benz. *360°: Business Transformation Journal*, *3*, 39–45. Retrieved from http://www.bta-online.com

Frankfort-Nachmias, C., & Nachmias, D. (2008). *Research methods in the social sciences* (7th ed.). New York, NY: Worth.

Gao, S., & Low, S. P. (2014). The Toyota Way model: An alternative framework for lean construction. *Total Quality Management & Business Excellence*, *25,* 664–682. doi:10.1080/14783363.2013.820022

Gijo, E., & Scaria, J. (2014). Process improvement through Six Sigma with Beta correction: A case study of manufacturing company. *International Journal of Advanced Manufacturing Technology, 71,* 717–730. doi:10.1007/s00170-013-5483-y

Glynn, A. N., & Quinn, K. M. (2011). Why process matters for causal inference. *Political Analysis*, *19*, 273–286. doi:10.1093/pan/mpr021

Godinho Filho, M., & Uzsoy, R. (2013). The impact of simultaneous continuous improvement in setup time and repair time on manufacturing cycle times under uncertain conditions. *International Journal of Production Research, 51,* 447–464. doi:10.1080/00207543.2011

Godinho Filho, M., & Uzsoy, R. (2014). Assessing the impact of alternative continuous improvement programmes in a flow shop using system dynamics. *International Journal of Production Research, 52,* 3014–3031. doi:10.1080/00207543.2013.860249

Green, S. B., & Salkind, N. J. (2008). *Using SPSS for Windows and Macintosh: Analyzing and understanding data* (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Guion, R. M. (1976). Recruiting, selection, and job placement. In M. D. Dunnette (Ed.), *Handbook of industrial and organizational psychology* (pp. 777–828). Chicago, IL: Rand-McNally.

Ha, D. (2013). A study of JIT and firm performance in US manufacturing between 1990 and 2009: A re-examination of Swamidass (2007). *International Journal of Production Research, 51,* 2887–2899. doi:10.1080/00207543.2012.748225

Haider, A., & Mirza, J. (2015). An implementation of lean scheduling in a job shop environment. *Advances in Production Engineering & Management*, 1, 5-17. doi:10.14743/apem2015.1.188

Hair, J. F., Jr., Black, W. C., Babin, B. J., & Anderson, R. E. (2009). *Multivariate data analysis* (7th ed.). Upper Saddle River, NJ: Prentice Hall.

Ham, W. K., & Park, S. C. (2014). A framework for the continuous performance improvement of manned assembly lines. *International Journal of Production Research, 52,* 5432–5450. doi:10.1080/00207543.2014.911420

Hawthorne, G., & Elliot, P. (2005). Imputing cross-sectional missing data: Comparison of common techniques. *Australian and New Zealand Journal of Psychiatry, 39,* 583–590. doi:10.1111/j.1440-1614.2005.01630.x

Hsieh, L. Y., Chang, K., & Chien, C. (2014). Efficient development of cycle time response surfaces using progressive simulation metamodeling. *International*

Journal of Production Research, 52, 3097–3109. doi:10.1080/00207543.2013.864055

Iuga, M. V., & Kifor, C. V. (2013). Lean manufacturing: the when, the where, the who. *Revista Academiei Fortelor Terestre*, 4, 404-410.

James, R., & Jones, R. (2014). Transferring the Toyota lean cultural paradigm into India: implications for human resource management. *International Journal of Human Resource Management, 25,* 2174–2191. doi:10.1080/09585192.2013.862290

Jayamaha, N. P., Wagner, J. P., Grigg, N. P., Campbell-Allen, N. M., & Harvie, W. (2014). Testing a theoretical model underlying the 'Toyota Way'—An empirical study involving a large global sample of Toyota facilities. *International Journal of Production Research, 52,* 4332–4350. doi:10.1080/00207543.2014.883467

Jenson, F., Dominguez, N., Willaume, P., & Yalamas, T. (2013). A Bayesian approach for the determination of POD curves from empirical data merged with simulation results. *American Institute of Physics Conference Proceedings, 1511,* 1741-1748. doi:10.1063/1.4789251

Kerzner, H. (2004). *Advanced project management: Best practices on implementation* (2nd ed.). New York: Wiley.

Kerzner, H. (2009). Project management: *A systems approach to planning, scheduling, and controlling* (10th ed.). New York: Wiley

Khan, M. S., Al-Ashaab, A., Shehab, E., Haque, B., Ewers, P., Sorli, M., & Sopelana, A. (2013). Towards lean product and process development. *International Journal of*

Computer Integrated Manufacturing, 26, 1105–1116. doi:10.1080/0951192X.2011.608723

Kim, S.-K. (2013). Lean practice case for improving service operations of donuts company. *Journal of Service Science and Management, 6,* 232–239. doi:10.4236/jssm.2013.63026

Klarin, M., Brkić, V. S., Golubović, T., Stanisavljev, S., Brkić, A., & Sajfert, Z. (2016). Production cycle time reduction in low and medium-low-tech companies: a case study for serbia. *Tehnicki Vjesnik / Technical Gazette, 23*(4), 1103-1108. doi:10.17559/TV-20140715130015

Kock, N., & Lynn, G. S. (2012). Lateral collinearity and misleading results in variance-based SEM: An illustration and recommendations. *Journal of the Association for Information Systems, 13,* 546–580. Retrieved from http://aisel.aisnet.org/jais/

Kumar, N., Kumar, S., Haleem, A., & Gahlot, P. (2013). Implementing lean manufacturing system: ISM approach. *Journal of Industrial Engineering and Management, 6,* 996–1012. doi:10.3926/jiem.508

Kumar, S. S., & Kumar, M. P. (2014). Cycle time reduction of truck body assembly in an automobile industry by lean principles. *International Conference on Advances in Manufacturing and Materials Engineering, 2014,* 1853–1862. doi:10.1016/j.mspro.2014.07.493

Laerd Statistics. (2015). *Ordinal regression using SPSS statistics.* Retrieved from https://statistics.laerd.com/spss-tutorials/ordinal-regression-using-spss-statistics.php

Lai, S.-Y., Tsai, C.-H., Wei, L.-Y., Li, R.-K., & Lu, M.-J. (2014). The dilemma of Toyota Production System implementation: A case study of Taiwan machine tool industries. *International Journal of Academic Research in Accounting, Finance and Management Sciences, 5*, 1–12. doi:10.6007/IJARAFMS/v4-i4/1401

Langdon, D., & Lehrman, R. (2012). *The benefits of manufacturing jobs*. Washington, DC: US Department of Commerce Economics and Statistics Administration.

Li, J. (2013). Continuous improvement at Toyota manufacturing plant: Applications of production systems engineering methods. *International Journal of Production Research, 51,* 7235–7249. doi:10.1080/00207543.2012.753166

Li, Q. (2013). A novel Likert scale based on fuzzy set theory. *Expert Systems with Applications, 40*, 1609–1618. doi:10.1016/j.eswa.2012.09.015

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

Liker, J., & Franz, J. (2012). The Toyota way: Helping others help themselves. *Manufacturing Engineering*, *149*(5), 87-95. Retrieved from http://www.sme.org/MEMagazine/Engineering-home.aspx

Lin, K.-W. & Kang, C.-J. (2012). A production model for galvanizing transmission towers. *International Journal of Organizational Innovation, 5*, 203–216. Retrieved from http://www.ijoi-online.org

Lu, D. (1989). *KANBAN just-in-time at Toyota.* Cambridge, MA: Productivity Press.

Ludwig, C. (2014). Leadership, efficiency, analysis & networking. *Automotive Logistics*, *17*(3), 44–49. Retrieved from http://automotivelogistics.media

Marodin, G. A., & Saurin, T. A. (2013). Implementing lean production systems: Research areas and opportunities for future studies. *International Journal of Production Research, 51*, 6663–6680. doi:10.1080/00207543.2013.826831

Martínez-Juradoa, P. J., Moyano-Fuentesa, J., & Jerez-Gómez, P. (2014). Human resource management in lean production adoption and implementation processes: Success factors in the aeronautics industry. *BRQ: Business Research Quarterly, 17,* 47–68. doi:10.1016/j.cede.2013.06.004

Miina, A. (2013). Critical success factors of lean thinking implementation in Estonian manufacturing companies. *Baltic Journal of Economics, 13*, 113–114. doi:10.3726/978-3-653-03785-2/15

Mitchell, K. R., & Wellings, K. (2013). Measuring sexual function in community surveys: Development of a conceptual framework. *Journal of Sex Research, 50,* 17–28. doi:10.1080/00224499.2011.621038

Monden, Y., (1983). The Toyota Production System, An integrated approach to Just-in-time, *Norcross, Georgia: Industrial Engineering and Management Press*, (2nd ed.) Institute of Industrial Engineers

Morgan, S. D., & Gagnon, R. J. (2013). A systematic literature review of remanufacturing scheduling. *International Journal of Production Research, 51,* 4853–4879. doi:10.1080/00207543.2013.774491

Mostafa, S., Dumrak, J., & Soltan, H. (2013) A framework for lean manufacturing implementation. *Production & Manufacturing Research, 1*, 44–64. doi:10.1080/21693277.2013.862159

Netland, T. (2013). Exploring the phenomenon of company-specific production systems: One-best-way or own-best-way? *International Journal of Production Research, 51,* 1084–1097. doi:10.1080/00207543.2012.676686

Nortje, F. D., & Snaddon, D. R. (2013). The Toyota Production System's fundamental nature at selected South African organisations—A learning perspective. *South African Journal of Industrial Engineering, 24,* 68–80. doi:10.7166/24-1-648

O'Leary-Kelly, S. W., & Vokurka, R. J. (1998). The empirical assessment of construct validity. *Journal of Operations Management, 16,* 387–405. doi:10.1016/S0272-6963(98)00020-5

Opara, E. U. (1995). *The empirical test of total quality management: An application of TQM at Chevron and its impact on productivity* (Unpublished doctoral dissertation). Golden Gate University, San Francisco, CA.

Ortega, E. M., Cordeiro, G. M., Hashimoto, E. M., & Cooray, K. (2014). A log-linear regression model for the odd Weibull distribution with censored data. *Journal of Applied Statistics, 41,* 1859–1880. doi:10.1080/02664763.2014.897689

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

Paraschivescu, A. O., & Căprioară, F. M. (2014). Strategic quality management. *Economy Transdisciplinarity Cognition Journal*, *1*(17), 19–27. Retrieved from http://etc.ugb.ro/

Parkes, A. (2015). Lean management genesis. *Management, 19,* 106–121. doi:10.1515/manment-2015-0017

Pedhazur, E. J. (1997). *Multiple regression in behavioral research* (3rd ed.). Orlando, FL: Harcourt Brace College Publishers.

Perez-Ortiz, M., Gutierrez, P. A., Hervas-Martinez, C., & Yao, X. (2015). Graph-based approaches for over-sampling in the context of ordinal regression. *IEEE Transactions on Knowledge and Data Engineering*, *27,* 1233–1245. doi:10.1109/TKDE.2014.2365780

Powell, D., Riezebos, J., & Strandhagen, J. (2013). Lean production and ERP systems in small- and medium-sized enterprises: ERP support for pull production. *International Journal of Production Research*, *51,* 395–409. doi:10.1080/00207543.2011.645954

Renna, P., Magrino, L., & Zaffina, R. (2013). Dynamic card control strategy in pull manufacturing systems. *International Journal of Computer Integrated Manufacturing*, *26,* 881–894. doi:10.1080/0951192X.2013.799783

Ringena, G., Aschehouga, S., Holtskogb, H., & Ingvaldsena, J. (2014). Integrating quality and lean into a holistic production system. *Procedia CIRP, 17,* 242–247. doi:10.1016/j.procir.2014.01.139

Rutledge, J., & Martin, L. (2016). Medical Taylorism, Lean, and Toyota. *New England Journal of Medicine,* 2, 1993. doi:10.1056/NEJMc1602596

Sahno, J., Shevtshenko, E., & Zahharov, R. (2015). Framework for continuous improvement of production processes and product throughput. *Procedia Engineering, 100,* 511–519. doi:10.1016/j.proeng.2015.01.398

Sanchez, L., & Blanco, B. (2014). Three decades of continuous improvement. *Total Quality Management & Business Excellence, 25,* 986–1001. doi:10.1080/14783363.2013.856547

Saraswat, P., Kumar, D., & Kumar, M. (2015). Reduction of work in process inventory and lead time in a bearing industry using mapping tool. *International Journal of Managing Value and Supply Chains, 2*(6), 27–35. doi:10.5121/ijmvsc.2015.6203

Schonberger, R. (2014). Quality management and lean: A symbiotic relationship. *Quality Management Journal, 21*(3), 6-10

Spatz, D. L., Froh, E. B., Schwarz, J., Houng, K., Brewster, I., Myers, C., . . . Olkkola, M. (2015). Pump early, pump often: A continuous quality improvement project. *Journal of Perinatal Education*, *24*(3), 160–170. doi:10.1891/1058-1243.24.3.160

Stout, G. A. (2014). *Improving the decision-making process for information security through a preimplementation impact review of security countermeasures* (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3215299)

Teich, S. T., & Faddoul, F. F. (2013). Lean management—The journey from Toyota to healthcare. *Rambam Maimonides Medical Journal*, *4*(2), 1–9. doi:10.5041/RMMJ.10107

Ţenescu, A., & Teodorescu, M. (2014). Lean manufacturing: A concept towards a sustainable management. *Communications in Applied Sciences, 1,* 97–110.

Tong, C., Niu, J., Xie, Z., & Peng, F. (2014). Sampling from social network to maintain community structure. *International Journal of Communication Systems, 27,* 1363–1377. doi:10.1002/dac.2815

Tonidandel, S., & LeBreton, J. M. (2011). Relative importance analysis: A useful supplement to regression analysis. *Journal of Business Psychology, 26*, 1–9. doi:10.1007/s10869-010-9204-3

Tsukada, O. (2013). Global dissemination of the Toyota Way in sales & marketing. *Journal of Knowledge Globalization, 6*(3), 53–76. Retrieved from http://www.kglobal.org/journal.html

Ullah, H. (2014). A Petri net model for the integration of purchasing, production and packaging using Kanban system. *Advances in Production Engineering & Management, 9*, 187–200. doi:10.14743/apem2014.4.187

Vidal, M. (2015). Industrialization, Fordism and the Golden Age of Atlantic Capitalism: The UK, USA and Germany from 1800-1973. In S. Edgell, H. Gottfried, & E. Granter (Eds.), *The Sage handbook of the sociology of work and employment* (pp. 284-286). Thousand Oaks, CA: Sage.

Villa, A., & Taurino, T. (2013). From JIT to Seru, for a production as lean as possible. *Procedia Engineering, 63,* 956–965. doi:10.1016/j.proeng.2013.08.172

Vujica Herzog, N., & Tonchia, S. (2014). An instrument for measuring the degree of lean implementation in manufacturing. *Journal of Mechanical Engineering, 60,* 797–803. doi:10.5545/sv-jme.2014.1873

Wagner, C., & Esbensen, K. H. (2015). Theory of sampling: Four critical success factors before analysis. *Journal of AOAC International, 98*, 275–281. doi:10.5740/jaoacint.14-236

Wang, J., Zhang, H., Liu, J., Zhang, K., Yi, B., Liu, Y., . . . Ji, Y. (2014). Implementation of a continuous quality improvement program reduces the occurrence of peritonitis in PD. *Renal Failure, 36,* 1029–1032. doi:10.3109/0886022X.2014.927771

Weaver, A., Greeno, C., Goughler, D., Yarzebinski, K., Zimmerman, T., & Anderson, C. (2013). The impact of system level factors on treatment timeliness: Utilizing the Toyota Production System to implement direct intake scheduling in a semi-rural community mental health clinic. *Journal of Behavioral Health Services & Research, 40,* 294–305. doi:10.1007/s11414-013-9331-5

Wilson, J. M. (2014). Henry Ford vs. assembly line balancing. *International Journal of Production Research, 52,* 757–765. doi:10.1080/00207543.2013.836616

Wisdom, J. P., Cavaleri, M. A., Onwuegbuzie, A. J., & Green, C. A. (2012). Methodological reporting in qualitative, quantitative, and mixed methods health services research articles. *Health Services Research, 47*, 721-745 doi:10.1111/j.14756773.2011.01344.x

Xanthopoulos, A. S., & Koulouriotis, D. E. (2014). Multi-objective optimization of production control mechanisms for multi-stage serial manufacturing-inventory systems. *International Journal of Advanced Manufacturing Technology, 74*, 1507–1519. doi:10.1007/s00170-014-6052-8

Yamada, K. (2014). Spurious correlation between economies and scale: Model T Ford revisited. *Annals of Business Administrative Science, 13*(4), 199–214. doi:10.7880/abas.13.199

Zaferullah, K. Z., & Kumar, S. (2013). Manufacturing excellence through JIT approach—A review. *International Journal of Application or Innovation in Engineering & Management, 2*(12), 302–305. Retrieved from http://www.ijaiem.org

Zarbo, R. J., Varney, R. C., Copeland, J. R., D'Angelo, R., & Sharma, G. (2015). Daily management system of the Henry Ford Production System: QTIPS to focus continuous improvements at the level of the work. *American Journal of Clinical Pathology, 144*, 122–136. doi:10.1309/AJCPLQYMOFWU31CK

Zhou, J., & Li, S. (2015). Distance based root cause analysis and change impact analysis of performance regressions. *Mathematical Problems in Engineering*, Article No. 690829. doi:10.1155/2015/690829

Ziegler, M., & Hagemann, D. (2015). Testing the unidimensionality of items. *European Journal of Psychological Assessment, 31*, 231–237. doi:10.1027/1015-5759/a000309

Appendix A: Informed Consent

CONSENT FORM

You are invited to take part in a research study about the productivity at Mercedes-Benz cars after the implementation of the Mercedes-Benz Production System. This research study is seeking responses from employees that work with Mercedes-Benz Production System; this general population will consist of present employees of Mercedes-Benz. The focus is collecting survey responses from operation's managers, plant managers, manufacturing engineers, and shop workers. I selected this group because they are involved in the daily activities related to productivity, cycle time, and employee headcount.

This form is part of a process called "informed consent" to allow you to understand this study before deciding whether to take part.

This study is being conducted by a researcher named Derrick Shaw, who is a doctoral student at Walden University.

Background Information:
The purpose of this study is to study how cycle-time variation, employee-headcount variation, and key performance indicators affected productivity of Mercedes-Benz cars from 1999 to 2017 after the implementation of the Mercedes-Benz Production System.

Procedures:
If you agree to be in this study, you will be asked to:

- Answer 10 general questions, 10 questions about productivity, 10 questions about cycle-time variation, 10 questions about headcount variation, and 9 questions about key performance indicators.
- If you agree to participate in the survey it will take about 10 minutes to answer the questions. The individuals involved in the study will be selected randomly from employees that work for Mercedes-Benz cars after the implementation of the Mercedes-Benz Production System.

Voluntary Nature of the Study:
This study is voluntary. Everyone will respect your decision of whether you choose to be in the study or not. No one associated with this research study will treat you differently if you decide not to be in the study. If you decide to join the study now, you can still change your mind later. You may stop at any time.

Risks and Benefits of Being in the Study:

Being in this type of study involves some risk of the minor discomforts that can be encountered in daily life, such as anxiety or upset. Being in this study would not pose risk to your safety or wellbeing.
The potential benefits in this research study are to help identify if variation in employee headcount and variation with cycle time negatively or positively impact Mercedes-Benz Productivity. The outcome of the study will determine if MBPS is effective which has a potential to remove or impact ergonomic risks; health and safety issues; and financial sustainability locally, nationally, and globally.

Payment:
This is an unpaid survey that will take about 10 minutes to complete and will be used for educational purposes.

Privacy:
Any information you provide will be kept confidential and anonymous. The researcher will not use your personal information for any purposes outside of this research project. Also, the researcher will not include your name or anything else that could identify you in the study reports. Data will be kept for a period of at least 18 years, as required by the university.

Contacts and Questions:
You may ask any questions you have now. Or if you have questions later, you may contact the researcher via email at derrick.shaw@waldenu.edu or (478)342-0357. If you want to talk privately about your rights as a participant, you can call Dr. Leilani Endicott. She is the Walden University representative who can discuss this with you. Her phone number is 612-312-1210 Walden University's approval number for this study is **IRB will enter approval number here** and it expires on **IRB will enter expiration date.**

Obtaining Your Consent

If you feel you understand the study well enough to make a decision about it, please indicate your consent by clicking the link below.

Appendix B: Description of Instruments and Letters of Permission

Hello Dr. Glenn Stout

My name is Derrick Shaw. I am a doctoral student at Walden University. Dr. Jeffrey Prinster is my Mentor. I am writing you to request permission to use a Survey Instrument published by you in 2006 for my dissertation. Please sign the form attached if you agree to grant permission to use your survey. I would also appreciate any additional information you can share for my use.

Thank you in advance for your consideration and time.

Derrick Shaw

Name / Date ________________________ / 3/1/16 ____________

Survey permission request Inbox x

Derrick Shaw <derrick.shaw@waldenu.edu>
to euopara

Dr. Opara,
I hope all is well! I am a doctoral student at Walden University. I would like permission to use a survey published by you in 1995. See the attachment and thanks for you time.

Regards,

Derrick Shaw

Opara,Emmanuel
to me

Mr. Shaw:

Yes, you can use the survey.

Cheers

Dr Emmanuel Uzoma Opara, F.I.I.M.A.
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Appendix C: Survey Questionnaire—Mercedes-Benz Production System

General					
1.	Do you agree with the above consent form and wish to continue with the survey?				
	Yes: Start the survey		No: Please end the survey		
2.	Mercedes-Benz cars are too bureaucratic.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
3.	Our organization has a well-developed vision of where it is going.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4.	I have a clear understanding of my supervisor's goals.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5.	I feel comfortable talking with my supervisor/manager.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
6.	Please choose A, B or C (from the list below) that best describes your current position:				
	(A) Technician or Assembler	(B) Engineer or Support		(C) Supervisor/Manager	
7.	Please choose how you identify yourself (please circle):				
	Male	Female			
8.	What was your age at your last birthday? ______				
9.	Have you worked for this organization "Mercedes-Benz cars" at any time between 1999 and 2017? (please circle):				
	Yes, Please Continue	No, please stop survey			
10.	How many years have you worked for this organization? ________				

Productivity

1. I am well informed about productivity expectations at my Mercedes-Benz manufacturing site.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

2. Notice about the productivity expectations is communicated to me.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

3. In the past I was prevented from doing things in the manufacturing process that I feel I should have been able to do in my job but could not, due to productivity restrictions in MBPS.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

4. The Mercedes-Benz Production System at my company interferes with productivity requirements for unnecessary reasons.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

5. The Mercedes-Benz Production System impedes my productivity.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

6. I would be more productive if the Mercedes-Benz Production System were not implemented.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

7. The workers have a voice in the productivity decisions in this company.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

8. I’m not very committed to productivity at Mercedes-Benz cars.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

9. I have a strong sense of commitment to productivity at Mercedes-Benz cars rather than to my job.

   Strongly Agree Agree Neutral Disagree Strongly Disagree

10. Our organization requires too many approvals that get in the way of my productivity.

    Strongly Agree Agree Neutral Disagree Strongly Disagree

	Cycle-time variation				
1.	I have to change the process that I normally follow to do my job because of the cycle-time variation.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
2.	I find ways to work around cycle-time variation when I can.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
3.	It is OK to work around cycle-time variation if you are still doing your job.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4.	The nature of my job caused me not to value cycle-time variation as it affects to productivity in MBPS.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5.	The success or failure of cycle-time variation in productivity really isn’t that important to me.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
6.	At Mercedes-Benz cars, success is mainly a matter of headcount in MBPS. It doesn’t matter how hard you work.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
7.	I would not care much about cycle-time variation, even if I owned Mercedes-Benz cars.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
8.	Having to adhere to cycle-time variation makes work demanding in MBPS.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
9.	Mercedes-Benz cars management adjusts cycle time to meet our organization’s unique needs.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
10.	Mercedes-Benz cars corporate management’s strategies effectively help us reach cycle-time variation goals.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

	Employee Headcount Variation				
1.	It seems like one day I am able to do something in the Mercedes-Benz Production System and the next I am not able to do that same action because of employee headcount changing. This happens:				
	Rarely	Once in awhile	Sometimes	Fairly frequently	All the time
2.	The production operations department at Mercedes-Benz cars changes employee headcount for no reason or benefit that I can see.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
3.	Workers have the ability to give advice about how employee headcount variation will impact their jobs.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4.	Headcount variation brings out the best in how I perform my job.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5.	Mercedes-Benz cars lacks "sense of urgency" in responding to headcount variation challenges.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
6.	Managers balance need for financial performance with concern for employee headcount variation.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
7.	Employees are encouraged to question why things happen the way they do with employee headcount variation.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
8.	Our corporation provides good information about employee headcount variation.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
9.	My organization effectively explains the needs of our employee headcount variation.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
10.	I feel free to speak my mind about how I feel about employee headcount variation.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

	Key Performance Indicators				
1.	My job teaches me key performance indicators that make me more valuable in the company's productivity.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
2.	I received adequate on training on key performance indicators when I started my job.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
3.	Key performance indicators about which I am knowledgeable, improved my job performance.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4.	My supervisor helps me develop plans to meet key performance indicators.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5.	My supervisor provides me with the key performance indicators I need to help productivity.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
6.	Productivity in my organization depends more on who you know and who knows you than on key performance indicators.				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
7.	These are key performance indicators I used in the production operations department:				
	Write in answer—				
8.	I think the Mercedes-Benz Car Company is doing a great job of measuring these key performance indicators.				
	Write in answer—				
9.	Please feel free to make list of key performance indicators used during your experience regarding MBPS, key performance indicators that impact your job, and any key performance indicators used in vain.				
	Write in answer—				