This is to certify that the

dissertation entitled

UNDERSTANDING THE DIFFUSION OF LEAN PRODUCTION:
THE INTEGRATION OF
TECHNOLOGY AND PEOPLE IN LEAN PRODUCTION

presented by

William Mark Mothersell

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Labor and Industrial Relations

Michael L. Moore
Major professor

Date August 24, 2000

UNDERSTANDING THE DIFFUSION OF LEAN PRODUCTION: THE INTEGRATION OF TECHNOLOGY AND PEOPLE IN LEAN PRODUCTION

By

William Mark Mothersell

A DISSERTATION

**Submitted to
Michigan State University
For the degree of**

DOCTOR OF PHILOSOPHY

School of Labor and Industrial Relations

August 2000

ABSTRACT

UNDERSTANDING THE DIFFUSION OF LEAN PRODUCTION: THE INTEGRATION OF TECHNOLOGY AND PEOPLE IN LEAN PRODUCTION

By

William Mark Mothersell

This study examined the extent to which technical and people systems of lean production, the interaction of these systems, and the integration of technical and people systems affects department performance, the perceptions of department performance, and work-related attitudes. A model was developed suggesting that the integration of technical and people systems will predict department performance, perception of department performance, and work-related attitudes.

Two manufacturing facilities from the automotive supplier industry participated in the study. A total of 533 employees provided survey data. The responses to this survey were used as a measure of people systems of lean production. A technical systems assessment instrument was used to measure the extent to which the technical systems of lean production had been implemented at the department level. The total of 51 technical systems assessment instruments were completed (n = 51). A total of 121 supervisors and superintendents provided survey data regarding perceived department effectiveness attributable to the implementation of lean production. Department archival performance data was provided by one of the two plants. Department performance measures included the number of employees to make at least one suggestion for the 1999 calendar year by department and shift as suggestion participation rate. Department

performance measures also included uptime by department and shift for an eight -month period (January through August, 1999). Complete archival data was provided for 26 departments (n = 26).

The results of this study suggest that people systems predict work-related attitudes and influence perceptions of department performance by employees. Specifically, people systems were significantly related to commitment to lean strategy, job satisfaction, learning environment, and team efficacy. Technical systems were strongly related to management perception of department performance. The people systems composite was significantly related to employee perceptions of department performance, but not people systems lean training. In contrast, the reverse relationship was shown for management perception of department performance. However, technical systems and people systems were not significantly related department archival performance data. People systems composite was found to moderate the relationship between technical systems and work-related attitudes (i.e., job satisfaction), and people systems lean training moderated the relationship between technical systems and work-related attitudes (i.e., team efficacy). Integration did not show a mediation effect on the relationship between technical systems and people systems with department archival performance. However, integration did have a direct effect on department archival performance.

DEDICATION

This dissertation is dedicated to my wife Jeannie for the freedom, to my daughter Natalie and my son Robert for their love, my parents for their unconditional support, and my brother Bob for the courage.

ACKNOWLEDGEMENTS

I have many people to thank for my success at Michigan State University. I would to thank my committee Michael Moore, Ed Montemayor, Peter Berg, Kevin Ford, and Dan Ilgen for their efforts in making this a better dissertation. I would like to thank the School of Labor and Industrial Relations and its faculty and staff for the opportunity to complete the Ph.D. program. The faculty and staff have always been available and supportive.

In particular, I would like to thank my chair and advisor, Michael Moore for his continuous and unwavering support throughout my Ph.D. program. I have had an opportunity to work closely with Michael Moore over the last few years. In addition to being intellectually engaging, he has provided incredible learning opportunities, and he has demonstrated remarkable support for students who are fortunate enough to get to know him, a trait I hope to carry forward with me. I would also like to specifically thank Kevin Ford who has provided support and guidance throughout much of my Ph.D. program and specifically for his assistance in completing the dissertation. Ed Montemayor has provided valued counsel and support throughout my time at Michigan State University and specific support with data analysis. Also, I would like to thank Dan Ilgen for his invaluable advice and Peter Berg for his assistance throughout my dissertation.

I would also like to thank the Work Practices Diffusion Team for the exciting and forever evolving research project. Shobha Ramanand has provided encouragement and friendship. John Schweitzer has provided analytical support and more importantly has instilled confidence throughout the data analysis phase of my research. Kristi White has provided kindness and great support. Randy Fotiu has provided SPSS and statistics advice and counsel, which saved me a tremendous amount of time.

Lastly, I would like to thank all those who supported this research project from the sites that participated in this study. While it is necessary to maintain confidentiality of the sites that participated in this study, I would like to specifically thank Johan for intellectual leadership and his initial support in providing entry for this study. I would also like to thank Beth and Bonnie for all of their long hours and valuable advice throughout this extended research project. Beth and Bonnie never complained about my requests despite their many other immediate pressures.

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CHAPTER ONE

INTRODUCTION

Introduction to the Study

U. S. manufacturing is currently undergoing a transformation of historical significance. In the late nineteenth and early twentieth centuries, manufacturing went through the transformation from craft to mass production (Ford, 1926; Piore, 1984; Taylor, 1967; Womack, 1990). Now, as we enter the twenty first century, mass production is giving way to a new paradigm described variously as lean production (Womack, 1990), agile production (Preiss, 1997), knowledge-driven work (Cutcher-Gershenfeld, 1998), flexible manufacturing (Piore, 1984), innovative-mediated production (Kenney, 1993), and sleek production (Handyside, 1997).[1] Documenting and understanding the core elements of this new approach to manufacturing is critical to the competitive success of U. S. industry.

This pressure on manufacturers is driven by global competitive pressure. In many segments of manufacturing, lean production has been viewed as the key to Japanese competitive success (Womack, 1990; Womack, 1996). As such, lean manufacturing has become a critical global business strategy for many manufacturers. However, others argue that it is not the mastery of manufacturing that explains the success of Japanese manufacturing industry. Rather, it is the capability of Japanese companies to continuously create organizational knowledge (Nonaka, 1995) as well as the intangible elements of the work system (Cutcher-Gershenfeld, 1998; Lin, 1995). By ignoring these people elements of lean production, organizations may be undermining the catalyst for achieving a competitive advantage. Yet, many manufacturers continue to benchmark and attempt to incorporate the technical aspects of the emerging production system and largely ignore or fail to fully appreciate the people elements.

What is curious about the current transformation is how few manufacturers have successfully imitated the Toyota Production System (TPS) (Spear, 1999). For example, GM, Ford and Daimler-Chrysler have independently created major initiatives to develop world-class production systems based on the TPS model. Automotive suppliers have also constructed major initiatives to develop and implement lean production (Moses, 1999). Yet, few organizations have reached the levels of manufacturing performance of Toyota.

This latest wave in the adoption of lean manufacturing is a system-wide perspective (Adler, 1993a; Kenney, 1993). This strategy attempts to adopt the entire lean production system and not borrow disconnected components of a larger system (Cutcher-Gershenfeld, 1998; Handyside, 1997). The elements of lean manufacturing, often discussed in the popular press include; Quality Circles, Employee Involvement, Statistical Process Control, Just-in-Time Inventory, Total Quality Management, Total Productive Maintenance, and Teams-Based Work Systems (Ohno, 1988; Toyota, 1992).

Manufacturers have increasingly adopted various components of lean manufacturing processes and practices with various levels of success (Keller, 1992). There has been considerable debate regarding what cultural components and human resource management practices and processes are consistent with, promote and sustain lean manufacturing (Adler, 1993b; MacDuffie, 1992). There is some evidence that team-based work systems and "high commitment" HR practices – including extensive training,

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[1] Lean production is currently the most used term to characterize this emerging paradigm. Lean production and lean manufacturing are used interchangeably to portray this new paradigm.

suggestion systems, and problem solving groups – are compatible with lean manufacturing (Arthur, 1994; Arthur, 1992; MacDuffie, 1995a; MacDuffie, 1995b). Yet, manufacturers' continue to struggle in putting the pieces together into a new cohesive whole.

Statement of the problem

The driver for change is clear. The MIT auto study (Womack, 1990) revealed a clear performance gap between the Japanese producers compared to the U.S., European and emerging auto producers (e.g., Korea, Brazil, and East Asia). For example, the MIT auto study identified the performance gap between the Japanese and U.S. producers as: (1) half the defects in finished cars; (2) half the hours of human effort in factories; (3) a tenth or less of in-process inventories; (4) half the factory space for the same output; and, (5) two-thirds of the product development time. This performance gap was not just a U.S. and Japanese phenomenon, but even larger gaps were revealed for the European producers and the emerging auto producers. The MIT auto study forcefully argued that the performance gap is attributable to lean production.

Importance of the Topic

Getting this mass to lean conversion process right has massive implications for U.S. industry. Hundreds of thousands of manufacturing jobs in U. S. industry are at stake. The major auto producers, General Motors, Ford, Diamler-Chrysler alone provide the main employment for many U. S. communities. Add in the automotive supplier base and millions of jobs can be seen as the stakes of a successful conversion.

While the implications for the U.S. economy are dramatic, the shift to lean production is a global phenomenon (Kenney, 1993; Rinehart, 1994; Shadur, 1995). This change has been an evolutionary process as manufacturers come to grips with intensive competition. That is, this is not a sudden and dramatic shift to new work practices, but a change that has emerged over the last 10-15 years (Adler, 1988; Cole, 1990; MacDuffie, 1997; Womack, 1996). During this period manufacturers have changed and developed work practices in ways that are consistent in some cases and inconsistent in other cases with the principal components of lean manufacturing. A key challenge for many manufacturing organizations is to identify and implement work practices that are fully integrated and maximize the full potential of lean production.

Research Need

This shift to lean production has been wide spread and has spurred increased research (Adler, 1993b; Florida, 1991; Klein, 1991). Much of this research activity in the U.S. has focused on the Japanese transplants (Jenkins, 1994; Jenkins, 1999). Another sector that appears to be making progress in adopting lean manufacturing is auto suppliers (Florida, 1996; MacDuffie, 1997). The big three auto companies in the U.S. have all initiated activities to adopt lean manufacturing as the predominate production system – in an effort to replace "Taylorist" mass production. The electronics industry has also been studied (Kenney, 1993; Kenney, 1995). Ironically, in the U.S. the electronics industry has largely accepted traditional U.S. mass production as well as traditional U.S. human resource and labor relations policies and practices. There are current activities in the aerospace industry that is attempting to apply the principles of lean production to both the public and private components of the aerospace industry (Womack, 1996).

Clearly there are significant efforts by many organizations as well as entire industries making the shift from mass to lean production and these efforts to become lean are not limited to the manufacturing industries. The technical elements of lean production have been extensively studied (Fry, 1987; Hyer, 1984; Womack, 1990). However, few empirical studies have directly studied the people elements of lean production and only one empirical study was found that examined the integration of the technical and people elements of lean production (MacDuffie, 1992). The people elements of lean production will be defined in Chapter Two.

Definition of Lean Production

Figure 1.1 provides an abbreviated comparison of lean and mass production. It is offered as an overview of some of the key differences in the two production systems. As can be seen in this Figure, there are a number of fundamental differences between lean and mass production. Some of these differences appear to be mirror opposites of one-another. For example, traditional mass production is often characterized as consisting of numerous job classifications, tightly supervised workers, with little or no job rotation, which results in deskilling of the workforce (items 2, 3, 4 and 6). In comparison, lean production can be characterized as using frequent job rotation, teams as a core building block of the production system, with few formal job classifications, which interact to develop and maintain a multiskilled workforce (items 12, 13, 14 and 16).

Figure 1.1

Production Systems: Comparison of Mass and Lean Models of Production

Mass Production	Lean Production
1. High levels of functional specialization	11. High levels of functional integration
2. Infrequent job rotation	12. Frequent job rotation
3. Tightly supervised, machine paced production work	13. Team-based production
4. Many job classifications	14. Few job classifications
5. Problem solving by experts	15. Kaizen (continuous improvement) by small group problem solving
6. Deskilled workforce	16. Multiskilled workforce
7. Work standards performed and imposed on workers	17. Team members and team leaders actively construct and improve work standards
8. Wages and promotion based on seniority	18. Wages and promotion based on seniority, merit and teamwork
9. Adversarial labor-management relations	19. Cooperative labor-management relations
10. Arms-length relations with suppliers, many suppliers, short-term focus	20. Tight inter-firm linkage with supplier, few suppliers, long-term focus

Adapted from (Cusumano, 1994; Florida, 1991; Jenkins, 1994)

Purpose of the Study

The purpose of this study is to increase understanding of the people elements that foster and support the technical elements in the diffusion of lean production. While the research and practitioner literatures are beginning to understand the management practices and processes that are necessary to encourage lean manufacturing, little empirical evidence is available to support their findings or define how individual and group attitudes relate mutually with the production system. Additionally, there is little empirical evidence that supports the position that investing in the people aspects of lean production has a positive impact on performance beyond the technical elements of lean production. This study will examine the relationship between the technical and people elements of lean production as well as the integration of these elements in the implementation of lean production. More specifically, this study will identify the key characteristics of lean production and link these characteristics with effectiveness data and work-related attitudes.

The technical elements of lean production will be defined by six factors that are crucial in the conversion to lean production. These six factors include: (1) flow manufacturing; (2) employee environment and involvement; (3) workplace organization; (4) quality; (5) operational availability; and, (6) material movement. The people elements of lean production will be defined by 13 factors, which include the following: (1) supervisory behaviors; (2) management support; (3) cooperative union-management relations; (4) development focus; (5) managing change; (6) teamwork; (7) involvement/psychological participation; (8) process focus; (9) proactive problem solving; (10) workplace trust; (11) workplace bonding; (12) workplace bridging; and, (13) conflict resolution climate. The mediating variable for assessing the level of integration is based on four items, which includes (1) The performance of standardized work; (2) Team work adjustments to match takt time; (3) Problem solving is used and consistently followed; and (4) That problem solving has become a methodology for management change. The dependent variables include department performance data, and individual and group work-related attitudes. Department archival effectiveness factors will include suggestions and productivity measures as well as perceived department performance. Department and individual work-related attitude factors will be defined by four factors, which include; (1) commitment to lean strategy; (2) job satisfaction; (3) perceived learning environment; and, (4) team efficacy.

The premise of this research proposal is that plants in the process of converting from mass to lean production fall into one of two quadrants. In Figure 1.2 below, traditional mass production (quadrant 1) brownfield plants will follow either a technologically focused approach to the diffusion of lean production (quadrant 4) or an integrated approach to lean production (quadrant 3). The technological approach to lean production will concentrate on the technical elements of lean production. Examples of the technical elements of lean production commonly presented in the literature (Ohno, 1988; Spear, 1999; Toyota, 1992; Womack, 1990) include the following: (1) inventory levels (e.g., JIT and kanban systems); (2) lot sizes for purchased or manufactured components; (3) standardized work; (4) andon boards and cords; (5) technology centered information systems; and, (6) error proofing processes.

While some organizations will be primarily centered on these technical elements of lean production, others will pay attention to the technical elements but also focus attention on the people elements of lean production. Some examples of the people elements of lean production include the following: (1) Process and product focus as opposed to solely a product focus; (2) Efforts to create a labor-management climate consistent with lean production; (3) The creation of a problem solving focus that allows workers to resolve problems at the lowest possible level (at their source); and, (4) The creation of a learning environment that allows idea generation and solution implementation.

Figure 1.2

Conversion Approaches of Brownfield Mass Production Plants into Lean Production Facilities

	Mass	Lean
High Commitment	(2) Sociotechnical Systems	(3) Integrated Approach
Low Commitment	(1) Traditional Mass Production	(4) Technology Centered Approach

The sociotechnical systems approach (quadrant 2) represents organizations that have adapted the social system to improve organization performance and quality of work life consistent with the STS perspective (Cherns, 1978). There are numerous examples of organizations that have undertaken such initiatives. Using the framework presented in Figure 1.2, this cell represents organizations that will be make the conversion from STS (quadrant 2) to lean production context, and will follow either an integrated approach (quadrant 3) or a technology centered approach (quadrant 4). Examples of organizations making this shift from STS to lean include Saab, Volvo, and the Ford Sharonville Plant. However, the participating organizations in this study are both traditional mass production plants (quadrant 1) converting to lean production (quadrant 3 or 4).

Accordingly, the conversion from STS to lean production will not be part of this study. This conceptual framework (Figure 1.2) will be more fully examined in Chapter Two.

The key assumption of Figure 1.2 is that organizations will follow one of two strategies in diffusing lean production. Some organizations will interpret and understand lean production as a technological innovation, while others will seek to understand and implement lean production based on employees playing a different role in lean production compared to traditional mass production systems. Plants converting to lean production using a people focused approach will also implement the technical aspects of lean production, but will do so in a way that encourages and involves employees substantially in the implementation and adjustments to the new work system.

This study explores both the technical elements and people elements of lean production as well as the integration of these elements in the conversion of brownfield plants into lean production facilities. Moreover, this study will assess the impact of these different approaches on department performance measures and work-related attitudes. This study will attempt to add insight into identifying what factors differentiate plants that pursue a technical approach to lean production versus an integrated sociotechnical approach. This integrated approach of people and technology in converting from to lean production is the key contribution of this study to the current body of knowledge.

Research Questions

The primary research questions for this study are: (1) Do departments that have implemented both the technical and people elements of lean production outperform those departments that have implemented just the technical elements of lean production? (2) Do departments that have integrated the technical and people elements of lean production outperform departments that have implemented just the technical elements of lean production and outperform departments that have implemented both the technical and people elements in an un-integrated way?

The Research Context: Automotive Supplier Industry

Automotive companies and parts suppliers have undertaken immense initiatives to convert established brownfield facilities into best-in-class lean production plants (Spear, 1999). At its core, the implementation of lean production in existing plants requires substantial rethinking of existing policies and practice as well as core assumptions and behaviors of employees, managers and union leaders (Bluestone, 1992; Kenney, 1993; Womack, 1990). The successful transformation of existing plants into lean production facilities is a critical and fundamental building block for the future of these companies. While some greenfield plants have been cited as lean production facilities, few brownfield plants within these competitors have made this transition successfully.

A distinction often cited in the literature is the differences between brownfield and greenfield facilities. A brownfield site is an existing enterprise or manufacturing plant that attempts to make a significant change within a current facility. For example, if an existing manufacturing plant attempted to implement team-based work systems, this would be a significant change initiative within a brownfield site. The term greenfield site is used to connote an effort by an organization to create some type of significant change initiative when it launches a new facility. Organizations will often attempt to create new work systems and practices when establishing a new work site and the hiring of a new workforce. For example, when a manufacturing firm launches a new facility, it might establish team-based work systems and fewer organizational levels from the outset.

This distinction between greenfield and brownfield carries with it a recognition that large-scale change is more difficult in a brownfield site. The reasons often given for the increased difficulty are associated with the unfreezing or unlearning that most occur before new routines can be learned and institutionalized. However, in the case of a greenfield, old routines, organizational structures, and preexisting cultures do not need to be changed and unlearned before an organizational change is implemented. The objective of a geenfield is to avert the entrenched work culture that might impede the introduction of new ideas and technology (Huczynski, 1987).

The difference between brownfield and greenfield is an important distinction for the study at hand. The organizations participating in this research are both brownfield facilities. The challenges these two organizations face in converting to lean production are very similar to what other manufacturers' face in attempting to make this transformation. If, as many argue (Kenney, 1993; Womack, 1990; Womack, 1996), most manufacturers most become lean producers to remain competitive or even survive in the future, then there are an enormous number of brownfield sites that most make this conversion. The lessons to be learned in the brownfield conversion to lean production have immense potential consequences at the local, state, regional, national and global level.

The manufacturing industry (Standard Industrial Code 20-39) is a critical part of the U.S. economy and in 1998 employed 16% of the U.S. workforce (BLS, 1998). As a percent of the total U.S. gross domestic product the manufacturing sector represented 17% of GNP in 1997 (BEA, 1997). Approximately one in six employees in the U.S. economy are directly employed in the manufacturing sector (BLS, 1998).

The competitive pressure on component suppliers has intensified as a result of efforts by the domestic automotive companies to reduce the number of suppliers. For example, General Motors (GM) and Ford Motor Company (Ford) has significantly reduced their number of suppliers, and the number of suppliers are projected to continue to decline. For example, between 1979 and 1991 the "Big Three" closed 80 manufacturing facilities (McAlinden, 1993). In 1999 GM spun off its supplier organizations and Ford and the United Auto Workers (UAW) reached an agreement that will allow Ford to spin off its supplier organizations in the coming months furthering the competitive pressure in the market place (McCracken, 1999; White, 1999a; White, 1999b). The competitive pressure in this industry has also increased by the number of foreign car companies locating facilities within North America. This has resulted in these companies relocating their respective preferred suppliers from their home countries to North America. As a result, some of the top global suppliers already are locating supplier plants in direct competition with the current supplier base in North America. In short, becoming a lean producer is critical to the long-term success and survival for many organizations within the automotive supplier industry.

Research Methods

The objective of this research is to study the effects of alternative approaches in the implementation of lean production. The research focuses on individuals and groups of individuals who make up the organization, their perceptions regarding the implementation of lean production, and the impact of alternative approaches on department performance. There are three key objectives to this study:

1. To investigate to what extent the integration of the technical and people elements of lean production affect department performance and work-related attitudes at the department level.

2. To investigate to what extent the people elements of lean production affect department performance and work-related attitudes at the department level.

3. To investigate to what extent the technical elements of lean production affect department performance and work-related attitudes at the department level.

The catalyst for this study resulted from the sheer size of the transformation currently taking place in the manufacturing sector with the immense academic opportunities inherent in such a large-scale change coupled with the enormous practical implications in the conversion of brownfield work sites into lean production facilities. This research will investigate the effects of different strategies or approaches to the implementation of lean production. It will assist in the identification of the changing roles of workers in this emerging work system and how it differs from traditional mass production. Therefore, this research is designed to identify the differential impact of the technical and people centered approaches, and more importantly the impact of the integration of the people and technical elements in the implementation of lean production.

Data were collected using multiple methods, which included the following: (1) survey data to assess the people elements of lean production; (2) an assessment instrument to measure the technical elements of lean production; (3) an assessment instrument to assess the integration of the technical and people elements of lean production; (4) archival performance data at the department level; (5) individual interviews of key organizational leaders and internal experts; and, (6) follow-up interviews with internal experts to provide understanding of the results of this investigation.

Multiple regression will be used to test the relationship between the technical systems, people systems and the integration of these elements of lean production with department performance and work-related attitudes. Multiple regression analysis permits the simultaneous analysis of multiple independent variables influence on dependent variables (Kerlinger, 1986:138). Multiple regression analysis allows for the assessment of whether each independent variable significantly predicts the dependent variable.

Contributions and Limitations of this Dissertation

This study will confine itself to the component industry supplying the automotive manufacturers and assemblers in North America. As such, clear generalization of the results will be limited to this industrial sector. While the company that participated in this study is a global manufacturer and international supplier of automotive component parts, it will be difficult to generalize outside the U.S. This study will be able to suggest that these same basic people and technical elements and the integration of these elements are necessary to fully capture the full potential of lean production across the industry and international boundaries. However, confirmation of this relationship will require future empirical research.

A cross-sectional survey design simultaneously surveys a number of different groups to assess differences at the time of the survey (Saslow, 1982:16). The primary limitation of a cross-sectional survey design is that the direction of the relationships between the independent and dependent variables cannot be determined. To obtain a clearer understanding of the relationships between the technical elements, people elements, the integration of these elements, and its impact on department effectiveness and work related attitudes would require longitudinal analysis. Another limitation in this study is the difficulty in obtaining common performance measures across departments. To compensate for this limitation, perceptions of department performance will be obtained from three different organizational levels (i.e., hourly workers, supervisors, and superintendents) from each site, which will allow for correlation analysis of perceived and actual department performance.

This study aims to provide key contributions to the existing literature. The lean production literature has largely ignored people issues and measurement. This study puts the people aspects of the production system center stage. The study identifies components of the people system and develops specific measures. This study also focuses at the department level by attempting to link workplace attitudes and department performance with lean production. The study uses multiple sources of data to test a model of people and technology integration. These data sources include workers, supervisors, superintendents and HR managers using both qualitative and quantitative instruments. In addition, this study contributes by assisting organizations in the diffusion of lean production.

Organization of this Dissertation

This dissertation will include five chapters. Chapter One provides the purpose for the study, the rationale underlying the research objectives as well as the potential contribution of this dissertation. Chapter Two contains a focused review of the sociotechnical systems and high performance work practice literature. The methods section is presented in Chapter Three. It includes the research design, organizations involved in the study, the subjects for this research, the data collection procedures, the operationalization of the variables, and the method for data analysis for each hypothesis. The results of the data analysis will be presented in Chapter Four. The conclusions, implications for theory and practice, and future research will be presented in Chapter Five.

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CHAPTER TWO

LITERATURE REVIEW

As stated in Chapter One, the purpose of this dissertation is to investigate the effect of alternative approaches to the diffusion of lean production on work-related attitudes and department performance. This research will test the effect of an integrated approach to lean production versus a more technology focused approach. This Chapter will present a conceptual framework that will be used to provide a focused review of the relevant theory and provide a foundation for analysis.

A Conceptual Framework for the Diffusion of Lean Production

Figure 2.1 presents a framework and perspective on converting brownfield mass production organizations to lean production. It will also furnish a foundation for comparative analysis and provide a basis to utilize existing theories. There are four characteristics of this perspective that will provide the foundation for this study.

The horizontal axis represents two major alternatives to manufacturing, which are mass and lean production. Both of these alternative production systems are briefly defined in Chapter One. The distinctions between lean and mass production has been extensively discussed in the practitioner and academic literatures. Whether a manufacturing organization is a mass versus lean production facility can be determined by assessing specific production practices. For example, assessing production practices such as inventory turns, part lot size, existence of standardized work, and usage and method of application of an andon system could be used to determine which category best characterizes a specific plant or work unit.

Figure 2.1

A Framework for A Comparative Analysis of Alternative Approaches in the Diffusion of Lean Production in Brownfield Sites

		Production Systems	
		Mass	**Lean**
People systems	**High Commitment**	Sociotechnical Systems	Integrated Approach
	Low Commitment	Traditional Mass Production	Technology Centered Approach

The vertical axis represents the people systems in the differing production systems. As can be seen in this framework, different people systems and practices can be applied in both mass and lean production systems. While, the literature is rich with descriptions of the differences and similarities in mass and lean production from a technical perspective, little in the behavioral sciences literature specifically address people systems in the context of the conversion from mass to lean production. The literature that does exist builds on the high performance work practices and sociotechnical systems perspectives. While much of the research in this area has been conducted in a mass production context, it provides a viable theoretical basis for this study. As such, these literatures will be used to provide the theoretical foundation for the vertical axis in the present study. For example, these literatures could be used in determining whether an organization has adopted a high commitment or low commitment strategy by assessing such factors as training and development efforts, employment security, selectivity in recruiting, incentive pay systems, levels of employee participation/involvement, and participation in suggestion systems.

The concept of high commitment and low commitment people systems has many different names in the academic and practitioner literature. For example authors use terms such as HR and IR systems (Arthur, 1992), HR bundles (MacDuffie, 1995b), high performance work practices (Becker, 1996), and social systems (Trist, 1978) in this literature. Distinctions are further delineated by conceptual frameworks such as downgrading and upgrading strategies (Susman, 1986), control and commitment (Walton, 1985), and administrative and human-capital-enhancing (Youndt, 1996). For the purpose of this paper the terms high commitment and low commitment people systems will be used. However, when a specific author or literature base is cited or discussed the terms appropriate to that citation will be used.

Using both the vertical and horizontal axis identifies four alternative characteristics of a work system. An organization that pursues a low commitment approach to people systems and a mass production strategy could be viewed as *traditional mass production* facility. These types of organizations could be characterized with technology systems such as high inventory levels, high number of repairs, poor visual management, and focused largely on production numbers. This type of organization low commitment people system strategies might consist of such policies as adversarial labor-management relations, low participation rates in suggestion systems, and control oriented supervision. Those organizations that fall within *the technology* *centered approach* to lean production would implement technology consistent with lean production (e.g., small lot size, standardized work, and visual controls), and retain low commitment people systems strategies (e.g., adversarial labor-management relations and control oriented supervision).

As can be seen in the framework, the upper left-hand corner of Figure 2.1 might be described as the application of *sociotechnical systems* in a mass production context. This has been an area of much research (Rice, 1953; Trist, 1951; Walton, 1972). While most of the sociotechnical systems (STS) research has been conducted in a mass production context, more recent research is beginning to use the STS perspective in a lean production context (Dankbaar, 1997; Niepce, 1998). Organizations that fall within the sociotechnical systems category would be those organizations that use current mass production technology, but pursue a high commitment people systems strategy. Organizations that fall within the *integrated approach* have converted to lean production both in terms of technology, but have also adopted high commitment people systems that are integrated with lean production.

In short, this study will use this framework to identify a theory base for this study and hopefully provide a basis for this research as well as future research. This four quadrant framework offers a foundation for comparing and contrasting organizations in terms of both the technical elements and the people elements of the work system as well as the integration of technology and people systems in the lean production context.

Sociotechnical Systems

The Tavistock Institute of Human Relations was founded in London in 1946 with the assistance of a grant from the Rockefeller Foundation. The Institute was founded with the specific purpose of actively relating the social and psychological sciences to the needs of society. The founding members of the Institute had been at the pre-World War II British Army Unit in the Tavistock Clinic and became known as the "Tavistock Group." The Tavistock Institute evolved into three theoretical perspectives, called the socio-psychological perspective, the socio-technical perspective and the socio-ecological perspective (Trist, 1990). The sociotechnical systems perspective is the appropriate theoretical framework for the study at hand.

The sociotechnical systems theory emerged from the Trist and Bamforth study of coal-mining in Durham England (Scarbrough, 1995). This seminal work by Trist and Bamforth (1951) contrasted the psychological and social problems associated with the Taylorist work organization of the prevailing "longwall" approach to coal mining with the pre-mechanization "shortwall" approach, in which multi-skilled autonomous teams of miners organized task responsibilities (Trist, 1951). In these early studies by Trist and others at the Tavistock Institute the researchers found in the mining industry that it was possible within the same technological and economic constraints to operate different systems of work organization with different social and psychological effects. These findings demonstrated the significant degree of organizational choice available to management to enable them to structure the social and psychological aspects of work (Pugh, 1997).

A key proposition offered by the STS perspective is that all work organizations are composed of two interdependent systems, a social and technical system. That changes in either the technical or social systems affects the other system. To obtain high organizational performance and employee satisfaction, organizations must optimize both the technical and social systems. Katz and Kahn accept the importance of the fit between the technical and social systems, but argue that some technical systems are compatible with several arrangements of the social system while others require a specific type of social system (Katz, 1978). Accordingly, a fundamental premise of the STS theoretical perspective is the importance of fit between the social and technical aspects of work (McCuddy, 1978) and that effective work systems must jointly optimize the relationship between these subsystems (French, 1995).

Given the assumption above that joint optimization is necessary for effective work systems, this proposition does not eliminate the possibility that they may differ in effectiveness. That is, that social systems may vary in a match with a technical system, but the adaptation of the social system may provide improvements in the effectiveness of the overall work systems. The question naturally arises of which social system will provide the optimum conditions as distinct from those that are just good enough for any given technical system (Trist, 1978).

More specifically, Bamforth argued that a production system could not be seen as a technical system or a social system but had to be seen in terms of both of these systems (Kelly, 1978). From this argument the matching or joint optimizing of the technical and social subsystems would result in effective performance typically defined in terms of output, morale, absenteeism, etc. (Kelly, 1978). If either of the systems are maximized at the cost to the other system would result in suboptimization of the work system.

An important criticism of the joint optimization of the social and technical research is that the technical system has rarely been altered in sociotechnical interventions. In the overwhelming majority of cases only the social systems have been altered, while the technical systems remained unchanged (Kelly, 1978). In those few cases were the technical system has been altered in conjunction with a sociotechnical intervention rarely has the change initiative been maintained for extended periods of time.

Kelly (1978) in his critical review of the STS literature specifically used machine utilization in the STS literature as proof that such efforts were designed to bring recalcitrant social systems into line. That is, that recalcitrant workers and social systems must be brought into alignment with the technology to maximize machine output. In fact, Kelly supports his position by arguing that STS scholars maintained as long ago as 1966 that the Tavistock studies had taken the technical system as given.

While these arguments illustrate important theoretical inconsistencies in the STS perspective, these same arguments are less relevant during the current transformational period. No longer are manufacturing organizations maintaining "Taylorist" mass production practices. For many manufacturers the ability to transform current technical practices into lean production practices is of critical importance and the core assumptions inherent in lean production are significantly different from a mass production environment. For example, the understanding and practice of machine utilization are fundamentally different in a mass versus lean context. As argued by Kelly, machine utilization in a mass production context is based on output maximization. In a lean production context, the key objective is not machine utilization based on output maximization, but throughput matched to customer demand. Machine utilization is counterproductive in a lean production setting. Maximizing machine utilization leads to high inventory levels, quality problems, increased costs, cluttered work areas, and the degradation of visual management if not matched to customer demand and designed for balanced throughput. Therefore, in the case of lean production the technical elements of the production systems are being altered unlike most of the prior studies conducted in a mass production context.

While the appropriate fit of the social system with the technical systems has been a key aspect of the STS theory from early in its formation, the issue remains unresolved. McCuddy (1978) identified key empirical research in conflict regarding the consonance hypothesis. The "consonance hypothesis" is the proposition that organizations will perform effectively only to the extent that their structures are compatible with the requirements and dictates of the technical system (Mohr, 1971). Several studies found support for this consonance hypothesis (Rice, 1953; Trist, 1951; Walton, 1972). However, Mohr (Mohr, 1971) directly challenged the consonance hypothesis. He argued that there is little evidence in the literature that the social structure of organizations is strongly affected by technology. In this study, Mohr found that routines and task interdependence were positively associated with technical systems and found no correlation with participativeness of supervisory style as the social structure dimension. Additionally, the author found no support for the proposition that the effectiveness of an organization is determined by the joint optimization of technology and social structure. In short, Mohr did not find support for the consonance hypothesis and as such challenged the key proposition of joint optimization.

High Performance Work Practices

The STS perspective has been criticized for failing to adequately define the social and technical systems (McCuddy, 1978). One of the earliest attempts to close this gap is the link between the STS and high performance work practices literatures (HPWP). Walton (Walton, 1985) identified "... two radically different strategies for managing a company's or a factory's work force, two incompatible views of what managers can reasonably expect of workers and the kind of partnership they can share with them" (Walton, 1985:85). The author describes these opposing approaches as control and commitment. The workforce strategies considered by the author in comparing control and commitment approaches included; (1) job design principles, (2) performance expectations, (3) management organization, structure, systems, and style, (4) compensation policies, (4) employment assurances, (5) employee voice policies, and (6) labor-management relations. Other researchers have since developed similar conceptual models that are consistent with the early work of Walton (MacDuffie, 1995b; Pfeffer, 1995; Schuler, 1989; Susman, 1986).

More recently, Adler and Docherty (1998) in response to this criticism articulated an important shift has that occurred since the 1950's and 1960's when STS theory developed. The authors argue that during this early period the STS perspective failed to adequately address the purpose of the work system to create customer value within existing social and resource constraints, failed to adequately address the context or external business environment, and failed to adequately include the dynamics of the sociotechnical system. A critical and primary goal for organizations in the current environment is to create value for its customers within certain resources and social constraints. The authors acknowledge as a major development the growing awareness by management and unions in many countries that strategy and business must be understood and accepted as a key basis for action at all levels in the organization (Adler, 1998). In addition, Adler and Docherty stated: "The key elements in efficiency and effectiveness for an organization differ depending on the environment in which it is working. If management regards the environment as stable or static, attention will be highly focused on rationalization, productivity, and profitability. Within the automobile industry, this strategy is often referred to as "Fordism" (i.e., mass production). If management regards the environment as characterized by change and turbulence, it will give high priority to competence development and the abilities to adjust, develop, and innovate. Within the automobile industry this strategy is often referred to as "Toyotism" (i.e., lean production) (Adler, 1998:321).

Susman and Chase (1986) provided a STS analysis of the integrated factory and offered a framework similar to that offered by Walton (Walton, 1985). In this framework the authors argue that an organization converting to an integrated factory has two different strategies available: (1) a down grading strategy; or, (2) an upgrading strategy. Each of these strategies carries with it inherent benefits and risks. The following Figure 2.2 is adopted from the Susman and Chase comparison of the benefits and risks of a downgrading versus an upgrading strategy (Susman, 1986:266).

Schuler (1989) offered a matching strategy of employee role behaviors with cost and market strategy. This approach offered by Schuler identified; innovation, quality and cost as three distinct competitive strategies and described key human resource management practices that would appropriately match each of these competitive strategies. The differing HR strategy types of innovation and quality would appear to be a further delineation of the high commitment strategy offered by Walton.

Figure: 2.2

Potential Benefits and Risks of a Downgrading Strategy versus an Upgrading Strategy

	Potential Benefits	**Potential Risks**
Downgrading Strategy	Lower skills Less pay Programmable tasks Turnover less of a concern Bargaining unit will shrink	Workers will not recognize key variances High costs of overhead Learning loop severed
Upgrading Strategy	Workers will recognize key variances Overhead will be lower Learning loop facilitated	Average payroll be higher Dependent on scarce human resources Workers' tasks are not programmable

In a study by Youndt, Snell, Scott, Dean, James, and Lepak (1996), the authors developed a similar approach. The authors explore the relationships among HRM practices, manufacturing strategy, and performance. The authors' framework for analysis included administrative and human-capital-enhancing approaches. The authors hypothesized that human-capital-enhancing HR systems would be positively associated with operational performance. The authors identified three manufacturing strategies often used by researchers; cost, quality, and flexibility. For the purpose of their study, the authors grouped the quality and flexibility strategy together with a human-capital-enhancing HR system. A cost strategy was grouped with an administrative HR approach. The findings supported a direct link between HR practices and operational performance. However, this effect was primarily the effect of linking human-capital-enhancing HR systems with quality manufacturing strategy. The findings show that HR systems can substantially influence performance when aligned with appropriate manufacturing strategies. For the present study, the administrative HR approaches is similar to the low commitment approach and the human-capital-enhancing HR system is similar to the high commitment on the vertical axis in Figure 2.1.

In a pair of studies by Arthur (1994; 1992), he identified two types of human resource systems, control and commitment. The author assessed how a pattern of HR practices are related to organizational strategy and performance. That is, how do different patterns of HR practices interact with firm strategy and impact organizational performance? In the 1992 study, Arthur found that IR systems[2] vary depending on business strategy (cost versus differentiation strategy). Figure 2.3 presents Arthur's configuration of IR systems.

The finding in Arthur's (1992) study were consistent with the conceptual model in which management selects a business strategy and in-turn shapes an appropriate industrial relations system. In a follow-up study, Arthur (1994) used the two configurations (control versus commitment IR systems) from the earlier study to evaluate whether the combination of the HR systems are useful in predicting performance in steel "minimills." The essence of the research design is presented in Figure 2.4.

The results support Arthur's contention. Commitment type HR systems were related to lower scrap rates and higher labor efficiency than control oriented HR systems. The results were mixed for employee turnover. For the study at hand, the studies by Arthur suggest that high commitment strategies can impact performance when designed to be in harmony with the manufacturing strategy.

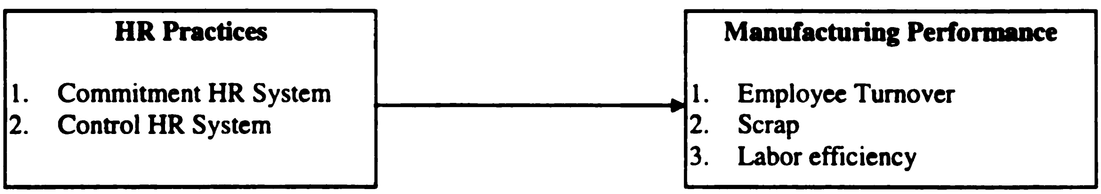
Figure 2.3

Two Systems of Workplace Industrial Relations

IR Systems	Types of System	
	Cost Reduction	**Commitment Maximizing**
Organization of Work	• Job task narrowly defined	• Broadly defined jobs
Employee Relations	• Very little employee influence over management decisions • No formal employee complaint/grievance mechanisms • Little communication/socialization effort	• High level of employee participation/involvement • Formal dispute resolution procedure (nonunion firms) • Regularly share bus./ economic information with employees
Staffing/Supervision	• Low skill requirement • Intense supervision/control	• High % of skilled workers • Self-managing teams
Training	• Limited training efforts	• More extensive, general skills training
Compensation	• Limited benefits • Relatively low wages • Incentive-based	• More extensive benefits • Relatively high wages • All salaried/stock ownership

Figure 2.4

Control and Commitment HR Systems in Predicting Manufacturing Performance



MacDuffie (MacDuffie, 1995b) also used a configurational approach by identify consistent "bundles" or systems of HR practices. MacDuffie was interested in whether innovative HR practices affect performance, not as individual HR practices, but as interrelated elements in an internally consistent HR "bundle" or system. Secondly, the author examined whether these HR systems contribute to assembly plant productivity and quality when they are integrated with manufacturing policies under the logic of a flexible

[2] Arthur used the terms HR systems and IR systems interchangeably.

production system (i.e., mass versus flexible production strategy). The study finds support for the proposition that "bundles" of internally consistent HRM practices are positively associated with higher employee productivity.

As indicated in the discussion above, several studies have examined the relationship between high performance work practices and firm performance (Arthur, 1994; Huselid, 1995). Other studies have been performed in a manufacturing setting and designed to study the impact of manufacturing strategy on HRM practices (Snell, 1992) or the relationship between business strategy and industrial relations systems in a manufacturing context (Arthur, 1992). However, few studies have been conducted that specifically examine the linkage between HR practices and polices in a lean production context.

Nevertheless, within a small group of researchers there has been considerable debate regarding what cultural components, human resource management and labor relations practices and processes are consistent with, promote and sustain lean manufacturing (Adler, 1993; MacDuffie, 1992; MacDuffie, 1995a; MacDuffie, 1995b). There is some evidence that certain key HR practices are compatible with lean manufacturing (MacDuffie, 1992; MacDuffie, 1995b).

Yet, the rationale of flexible or lean production systems implicitly require different approaches to managing human resources (MacDuffie, 1995b). MacDuffie suggests that innovative HR practices affect performance as a set of interrelated bundles or systems and that these bundles contribute most to performance outcomes (productivity and quality) when integrated with flexible manufacturing strategies. MacDuffie argues that, at least in the assembly plants he studied, innovative HR practices make little sense in a mass production context, yet innovative HR practices in a lean production context has a positive impact on operational performance.

Youndt, Snell, Dean & Lepak (1996) provided some additional evidence that flexible manufacturing does in fact require different HR systems. The authors found that manufacturing strategy moderated the relationship between HR systems and operational performance. That is, different bundles of HR practices are better aligned with flexible manufacturing, and these bundles, combined with flexible manufacturing, have a positive impact on operational performance. However, the authors argue that manufacturers pursuing cost containment, as opposed to flexibility, may be better off not investing in human-capital-enhancements. These findings suggest that there may not be one universal or best-practice approach to HR systems that is optimal for lean production.

While the integration of HR systems with lean manufacturing appears to be critically important to many organizations, the research evidence is very limited. Some qualitative research has provided some useful frameworks and added insight. For example, Kochan and Lansbury (1997) provided a topical framework that summarizes an international project that evaluates the diffusion of lean production and employment patterns. The employment relations practices studied by the authors included; (1) work organizations; (2) skill formation and development; (3) remuneration and compensation; (4) job security and staffing; and (4) enterprise governance and labor management relations.

Cutcher-Gershenfeld and associates (1998) offered a similar framework in the analysis of the transfer and diffusion of Japanese work practices to the U.S. The authors argue that U.S. mass production practices contrast sharply from lean production practices in Japan. The specific HR systems these authors present in their analysis included; (1) recruitment and selection; (2) training; (3) compensation and reward systems; (4) communication systems; (5) team-based work systems; (6) Kaizen; (7) employment security; and (8) labor relations.

These examples of qualitatively based frameworks need to be empirically tested. While such research might argue that these practices interact with manufacturing processes to enhance firm performance, these findings are only suggestive. Upon empirical investigation, these specific practices and policies may not directly or indirectly have a positive impact on performance. For example, while some argue that employment security is critical to the successful adoption of flexible production (Bamber, 1992; Cutcher-Gershenfeld, 1998), some empirical research has not found support for this proposition (Osterman, 1994).

Studies within the HPWP have been conducted in many industries. Some of the earliest work was in coal mining and shipping industries (Trist, 1990) and more recent studies include the steel industry (Berg, 1999; Ichniowski, 1997), steel minimills (Arthur, 1994), the apparel industry (Appelbaum, 2000) as well as many others. In a review article by Becker and Gerhart (1996) the authors provided a review of the current empirical literature regarding HPWP and enhanced performance outcomes. Of the five empirical studies cited by Becker and Gerhart only the study by MacDuffie (1995b) was directly related to lean versus mass manufacturing strategy and performance. Yet, the high performance work practices when applied to a lean production context suggests bundles of innovative HR practices will positively impact firm or plant performance.

Making this connection between the HPWP literature and the diffusion of lean production is an area in need of future research.

Integration

In this section, I will examine the theoretical and seminal studies that support why the integration of the technical and people elements will be positively and significantly related to department performance and work-related attitudes. Only two empirical studies have been located that speak specifically to integration in a lean production context (Dean, 1991; MacDuffie, 1992). Each of these studies will be reviewed and related to the study at hand.

Dean and Snell (1991) identified the primary purpose for their study was to construct a conceptual framework that characterizes the new manufacturing paradigm and to develop theory about the impact on jobs. While the authors used the term "integrated manufacturing," the publication followed shortly after the printing of The Machine that Changed the World, which coined the term lean production (Womack, 1990). Dean and Snell identify the following as distinguishing features of new manufacturing practices: (1) Advanced manufacturing technology (e.g., computer based technologies such as computer aided design, manufacturing and engineering); (2) Just-in-time inventory control (i.e., a system to reduce lead time, reduce inventory, and hence reduce costs); and, (3) Total quality management (i.e., the philosophy; do things right the first time, strive for continuous improvement, and understand and meet customer demands, as well as specific practices such as SPC, quality function deployment, and Taguchi methods) (Dean, 1991:777-778). While this is a limited definition of lean production, it clearly is related to the emergence of lean production as the dominant production paradigm. The authors argue that each of the above are a different aspect of integrated manufacturing, which is a paradigm of manufacturing management whose core concept is the elimination of barriers between different facets of a manufacturing operation. Manufacturing organizations attempt to eliminate these barriers by integrating the stages of production, by integrating functional departments, and by integrating manufacturing goals across the organization.

The theoretical concept provided by Dean and Snell are related to the current study in that each of these integration mechanisms converges at the shop floor worker. A critical missing element in the framework offered by Dean and Snell is the integration that must occur at the level where value is added to the product. Consequently, this study provides a fourth critical element in achieving the full potential of lean production which is the integration of the technical systems and people systems at the level of the shop floor worker.

The Dean and Snell (1991) survey study was conducted in the metal-working industry (Standard Industrial Classifications 33, 34, 35, and 37). Plants not manufacturing firms were the unit of analysis. The surveys were mailed to plant managers, functional managers, human resource managers, and non-managerial employees. The valid data included 160 plant managers, 90 human resource managers, 102 operations managers, 109 quality managers, 97 production control managers, and 456 non-managerial employees distributed across the functional manager categories.

MacDuffie and Krafcik (1992) identified two propositions in their study. First, that the link between the minimization of buffers and the extensive development of human resources capabilities under lean production contributes significantly to productivity and quality. Second, that advanced technology will contribute more effectively to manufacturing performance under lean production than under mass production (quality and productivity). The authors base these propositions on the premise that the "organizational logic" of lean production is significantly different from a mass production context. "Mass production uses highly specialized resources (both equipment and people) applied to the high-volume production of standardized products to achieve economies of scale. To ensure that these economies can be achieved, the production process must be protected as much as possible from disruptions (such as sales fluctuation, supply interruptions, equipment breakdowns) by large buffers – of inventory, repair space, extra equipment, and utility workers. These buffers moderate the tight coupling among steps in the production process, which minimizes the impact of contingencies" (MacDuffie, 1992:210).

In contrast, in a lean production context the "organizational logic" is significantly different. "…in a lean production system the stimulus to achieving cost and quality improvement is the reduction of buffers, which has both a direct effect (e.g., reducing the carrying cost of inventories), and a more significant indirect effect providing valuable information about production problems and an ongoing incentive to utilize that information in incremental problem-solving activity. While the reduction of buffers can promote this problem-solving approach, it will be effective only when human resource policies are in place that generate the necessary skills in the work force and create a sense of reciprocal commitment between company and worker" (MacDuffie, 1992:211-212).

The logic offered by MacDuffie and Krafcik is related to studies that attempt to identify the appropriate or best HR policies as well as specific practices that will assist in achieving the most of lean production. Or from an STS perspective, the authors examine the consonance between the technical and social systems in a lean production context. However, this study differs in important ways from this research stream. In this study, it is proposed that very specific integration activities must occur. These early studies attempted to identify the appropriate array of HR policies and practices that best fit lean production. While MacDuffie and Krafcik define where integration occurs when discussing "incremental problem solving," yet provide empirical data and offer specific HR policies at a different level. This study, in contrast, investigates integration practices at the shop floor level where in part MacDuffie and Krafcik provide the logic for their study.

MacDuffie and Krafcik were part of the research team that initiated the International Assembly Plant Study in 1989. The survey data used for this study was part of this larger international study. The sample consisted of 62 assembly plants from 6 different global regions from high volume product assemblers (versus luxury/specialty product category). The regions identified in the study included: (1) Japan, (2) Japanese-parent plants in North America, (3) U.S.-parent plants located North America, (4) Europe, (5) New Entrants, including East Asia, Mexico and Brazil, and (6) Australia.

The MacDuffie and Krafcik study found support for two relevant research questions for the study at hand. The research findings supported the proposition that the link between the minimization of buffers and the extensive development of HR capabilities under lean production contributes significantly to productivity (hours per vehicle) and quality (defects per 100 vehicles). Also, the study findings supported the premise that advanced technology will contribute more effectively to manufacturing performance under lean production than under mass production.

Other important results were also reported in this study. The Use of Buffers and HRM Policies were highly correlated ($r = .65$), which supports the "organizational logic" proposed by the authors. The Production Organization Index (which consists of a series of measures for the Use of Buffers and HRM Policies) was strongly correlated with performance ($r = -.59$) and quality ($r = -.63$). In sum, 36% of the variation in both quality and productivity for this sample is explained by the Production Organization Index alone. The authors also found that the Use of Buffers and HRM Policies contribute almost equally to the strong relationship between Production Organization Index and productivity. Yet, with quality as the outcome measure, the HRM measure is the most influential component. This finding suggests that is may be possible to minimize buffers as a cost reduction strategy, resulting in improved productivity without altering the plant processes that lead to high quality. This would support the basic premise of this study that two alternative approaches have emerged: (1) a low commitment lean production strategy, and, (2) high commitment lean production strategy. The authors argue that these findings support their proposition that the reduction in buffers must match HRM policies that improve problem solving capacity.

The technology measures also had statistically significant relationships with productivity and quality (Total Automation Index with productivity = r -.67 and with quality = -.41; Robotic Index with productivity = -.55 and with quality = -.41). And, the correlation of Total Automation with productivity and quality is much stronger for lean production than mass production.

In exploring the integration hypothesis for overall manufacturing performance, the authors' found that the amount of technology does not differentiate among the top three performing categories of assembly plants. However, the Production Organization index, including the component measures do differ significantly across the top three performing groups. And, the best performing category had the most lean production system, the most minimal buffers, and the most high-commitment HRM policies. This suggests that technology and production organization are important factors in explaining manufacturing performance when examined independently and contribute most significantly to high productivity and high quality when they occur simultaneously. As such, the authors suggest that technology has an important role in boosting performance as plants move from very low levels of automation to moderate levels, even in a mass production context, when both quality and productivity are jointly considered. However, the performance gain in moving from moderate to high levels of automation appears to occur only when linked with organizational, human resources, and manufacturing practices of a lean production system.

This study builds on the STS approach by analyzing the technical and social elements of work by evaluating two plants in the midst of a massive conversion from mass to lean production. The goal is to determine whether investing in the social elements of the larger work system impacts department performance and work-related attitudes at the department level. The joint optimization aspect of the STS perspective suggests that lean production will either fit with only one social system or that a number of social systems provide viable options in maximizing the effectiveness of the work system. Using the framework in Figure 2.1 and consistent with the STS and high performance work practice literatures two alternative people systems are proposed; (1) low commitment people systems; or (2) high commitment people systems. This study will use this theoretical basis coupled with the conceptual framework to assess whether these alternative approaches to people systems impact department effectiveness and work-related attitudes. Also, this study will assess the relationship of integration practices as a partial mediator between the technical and people systems with the dependant variables. In addition, this research will provide additional insight into the consonance hypothesis.

Hypotheses

The review of the academic literature and the conceptual framework offered in Figure 2.1 indicates that links between people systems, technology systems, and the outcomes measures are probable. Yet, empirical tests of these relationships need to be performed. The first step is to draw a direct link between the key technical systems and people systems of lean production and the dependent variables (department performance, perceived performance, and work-related attitudes). While it is expected that the implementation of the technical elements of lean production will be positively and significantly related to both perceived performance as well and actual department performance, this relationship needs to be confirmed. Many studies have demonstrated a strong correlation between actual measurable performance and individual perceptions of performance and will be used in this study to strengthen the validity of the relationships between the independent and dependent variables. Rooted in these earlier studies and the practitioner literature it is expected that the implementation of the technical elements of lean production independent of any adjustment to the people systems will result in improved performance. Based on this discussion, the following hypotheses are proposed:

H1: Technical Systems of lean production are positively and significantly related to department performance.

H2: Technical Systems of lean production are positively and significantly related to perceived department performance.

The next step is to assess the relationship between people systems and the dependent variables. The STS perspective posits that to achieve maximum organizational performance and positive work-related attitudes both the technical and social systems must be optimized. The findings by MacDuffie and Krafcik (1992) suggest that people systems will have a direct impact on performance in a lean production context. The matching of the technical and people systems to optimize organizational effectiveness is typically defined by output and worker attitudes. While the social system aspect of the joint optimization framework remains unresolved in terms of its relationship to performance outcomes, the high performance work practice literature has more consistently found a relationship between people systems and performance. Other researchers have found that high commitment people systems relationship with firm performance are moderated by manufacturing strategy, which suggests that appropriately designed people systems will impact organizational performance when matched with lean production. Based on this discussion, the following hypotheses are offered:

H3: People Systems of lean production are positively and significantly related to department performance.

H4: People Systems of lean production are positively and significantly related to perceived department performance.

H5: People Systems of lean production are positively and significantly related to work-related attitudes.

As stated above, a fundamental premise of the STS literature is the importance of fit between the social and technical aspects of work. Moreover, that effective work systems must jointly optimize the relationship between these systems. However, this premise has remained unresolved in mass production context, and has not been directly addressed in a lean production context. As stated above, the "consonance hypothesis" is the proposition that organizations will perform effectively only to the extent that their social structures are compatible with the requirements and dictates of the technical system. While limited, the research in a lean production context suggests that people systems must fit the technical elements of lean production to achieve optimal performance. Based on this discussion the following hypotheses are proposed:

H6: The consonance between the technical systems and people systems in lean production is positively and significantly related to department performance.

H7: The consonance between the technical systems and people systems in lean production is positively and significantly related to perceived performance.

H8: The consonance between the technical systems and people systems in lean production is positively and significantly related to work-related attitudes.

The integration literature suggests that a fundamental concept in lean production is the elimination of barriers between different facets of a manufacturing process. A key mechanism to eliminate these barriers is integration activities at the source where value is added. As discussed above, this study will attempt to identify integration activities as a partial mediator for both the technical and people systems of lean production. Hence, empirical tests of these relationships need to be performed. Based on this discussion the following hypothesis are offered:

H9: The relationship of the technical systems and people systems with department performance will be partially mediated by integration practices.

H10: The relationship of the technical systems and people systems with perceived performance will be partially mediated by the integration practices.

H11: The relationship of the technical systems and people systems with work-related attitudes will be partially mediated by the integration practices.

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CHAPTER THREE

RESEARCH METHODOLOGY

The purpose of this chapter is to describe the methodology used in this research. Based on the previous discussion, a model was developed that examined the relationships between people systems, technical systems, integration systems, department performance and, worker-related attitudes. This chapter introduces the organizations under study, provides a review of measurement issues, reviews the data collection procedures, and reviews the data analysis procedures.

Gaining Access

A common difficulty in field research is gaining access. This study then, like many before it, and many to follow, found it difficult and time consuming to gain access to conduct research in a field setting. What follows is a brief discussion of the protracted negotiations involved in securing access to the research sites.

This study began with contacts with a key human resource (HR) leader within a large global manufacturer. The manufacturer was looking for expertise in lean production related to organizational change in new plant start-ups and existing brownfield facilities. This researcher had been involved with both practitioners and academics for some time in the area of lean production and was looking for entry into manufacturers engaged in implementing lean production to conduct this dissertation research.

This researcher first met this key human resource leader in April of 1998. While the HR leader was looking for assistance, what emerged was an exchange that included right of entry to manufacturing sites for conducting research. After numerous meetings between April 1998 and December 1998 with the key HR leaders as well as meetings with staff personnel and three European experts in lean production, the HR leader agreed to begin work on securing site access to conduct this research. At this time, the HR leader agreed to meet with a top manufacturing leader within the corporation with expertise in lean production to identify four appropriate research sites. This then set in motion a series of meetings at each of these four sites to further pursue access.

Between January and May of 1999, this researcher met with representatives from each of these facilities on numerous occasions. Two of these facilities were located in Europe. The German location, after three conference calls, the review and discussion of two research proposals, and a meeting with the plant manager, HR managers, and operations manager, decided not to support the research at their site. This final decision was made in May 1999.

The second European site located in Belgium decided that they would participate in the study after several meetings (two with the plant manager and two separate meetings with the HR , lean production, and employee development managers), conference calls, and revisions to a research proposal. The initial discussion with this plant began in November of 1998 and agreement was not reached until September 1999. Given time constraints and needs of this researcher, this site is not included in this study. However, research continues in this site and will come to fruition in the summer of 2000.

The two sites located in the U.S., and the data used for this study, agreed to participate after several meetings with numerous individuals within each location. Conference calls and meetings began at both locations in January 1999 and agreement was not reached until May of the same year. Both sites required meetings with the HR manager, plant manager, and operations managers. Meetings were then scheduled with union leaders and staff personnel. In the case of the plant located in the Midwest, two meetings were held with joint plant steering committees before access was granted. Once both plants agreed to the study, a final review of the proposal was requested by public relations at the central office.

Finally, in May 1999, the study got under way. Yet, both facilities had one last request, that all data to be collected from unionized employees had to be collected before July 1, 1999. The labor contract at these facilities was due to expire and as a result the union and management representatives did not want the research to become a point of conflict. The alternative was to postpone the study until after agreements were reached at both facilities, but no guarantee to access at that time would be granted. As it turns out the decision to move forward with the July 1, 1999 deadline was the correct decision. One of these plants did not reach a final labor agreement until January 2000. Deciding to wait would have added at a minimum an additional eight or nine months to this research project.

The Research Sites

In this study there are two manufacturing sites from the same large global corporation that participated in this study. One of the facilities is located in the Southeast and the other is located in the Midwest. These plants supply the automotive industry with car and truck parts and pre-assembled sub-components. The hourly workforce at each location are represented by the same national union, but belong to different local unions. Both research sites are multi-plant locations.

Both plants have a history of workplace innovation. Like many other plants, these facilities adopted workplace innovation in a piecemeal approach. The common history of these adoptions is the failure to maintain these innovations. For example, each plant has adopted such innovations as statistical process control (SPC), quality circles, team-based work systems, just-in-time, and standardized work. The common cause cited in interviews of key personnel as to why these innovations were not maintained is the lack of a clear vision or systematic understanding of lean production as well as an understanding of how the pieces of lean production fit together into a cohesive whole. For these two facilities the piecemeal adoption of these practices converged with the development by the central office of a vision for manufacturing strategy in the middle of the 1990's. This strategy and implementation plan provided a common manufacturing vision and implementation strategy to encourage and accelerate the implementation of lean production. Despite this common vision and implementation strategy each facility still faced and continues to confront the challenge of shaping the adoption of lean production to their unique circumstances.

Plant Located in the Southeast

The plant located in the Southeast began operations in 1980. At the time of the study, the plant had approximately 1300 employees and the facility occupied approximately 646,000 square feet. The plant produces approximately 150 end items, and its primary products include halfshafts, intermediate shafts, power steering hoses, and tie rods. The plant consists of 563 machines with 8 % located in assembly, 82 % used as process equipment, and 10 % welding and forming machines. The plant's primary customers include General Motors, Saturn, Saab, Toyota, Volkswagen, and Volvo.

Plant Located in the Midwest

The plant located in the Midwest began operations in 1966. At the time of the study the plant had a workforce of approximately 1900 employees and the facility occupied approximately 645,000 square feet. The plant produces approximately 222 end items and its primary product supplied to automotive assembly plants is steering columns. The plant consists of 1044 machines with 16% located in assembly, 26% used as process equipment, 30% in welding and forming machines, and 24% in plastic injection machines. Its primary customers include Chrysler, General Motors, and Toyota.

The Sample of Subjects

The sample of subjects included 471 hourly employees and 62 salaried employees from the participating organizations for a total of 533 respondents. Employees from all functional areas were included in the pool of subjects for survey administration. Given the focus of this study the subsequent functional areas were specifically targeted to complete the survey and the number of respondents by functional area is as follows: (1) Assembly operations (248 respondents); (2) Component operations (162 respondents); (3) Quality assurance (37 respondents); (4) Support areas (e.g., skilled trades, cleaners, tool crib attendants) (38 respondents); (5) Production control & logistics/materials management (7 respondents); (6) Engineering (23 respondents); (7) Appointed and elected union officials (6 respondents) and, (8) All others (14 respondents). Table 3.1 provides an overview of respondents by functional areas.

Table 3.1

Number of Respondents by Functional Area, Plant Location and Total

	Midwest Plant		Southeast Plant		Total	
Function	**Total**	**Percent**	**Total**	**Percent**	**Total**	**Percent**
Assembly	194	62.8	54	23.9	248	46.5
Components	47	15.2	115	50.9	162	30.4
Quality Assurance	18	5.8	19	8.4	37	6.9
Support Functions	19	6.1	19	8.4	38	7.1
Production Control	4	1.3	3	1.3	7	1.3
Engineering	15	4.9	8	3.5	23	4.3
Appointed/Elected Union Officials	5	1.6	1	0.4	6	1.1
All Others	7	2.3	5	2.2	12	2.3

Demographic Data

Demographic data collected in this study included several items of potential interest to the research sites and this study. Each survey identifies what shift the employee works, years of service in the specific plant, age of the employee and functional area is identified. Gender and race are recorded. Hourly or salaried employee status is identified as well as whether the person completing the survey supervises other employees. Table 3.2 provides a demographic profile for this sample.

Table 3.2

Demographic Profile by Plant Location and Total

	Midwest Plant		Southeast Plant		Total	
Item	**Total**	**Percent**	**Total**	**Percent**	**Total**	**Percent**
Shift						
First	183	59.4	142	56.6	325	58.2
Second	107	34.7	63	25.1	170	30.5
Third	18	5.8	45	17.9	63	11.3
Gender						
Female	90	29.6	62	26.7	152	28.4
Male	214	70.4	170	73.3	384	71.6
Years of service						
1-2 years	41	13.4	17	7.4	58	10.8
3-5 years	36	11.7	19	8.2	55	10.2
6-10 years	14	4.6	13	5.6	27	5.0
11-20 years	50	16.3	113	48.9	163	30.3
21-30 years	128	41.7	60	26.0	188	34.9
More than 30 yrs.	38	12.4	9	3.9	47	8.7
Age						
18-25 years	17	5.6	3	1.3	20	3.7
26-30 years	16	5.2	6	2.6	22	4.1
31-35 years	8	2.6	12	5.2	20	3.7
36-40 years	19	6.2	37	15.9	56	10.4
41-45 years	77	25.2	70	30.2	147	27.3
46-50 years	96	31.4	44	19.0	140	26.0
51-55 years	52	17.0	44	19.0	96	17.8
Over 55 years	21	6.9	16	6.9	37	6.9
Race						
African American	22	7.4	27	11.9	49	9.3
Caucasian	244	81.6	160	70.5	404	76.8
Hispanic	11	3.7	0	0.0	11	2.1
Native American	15	5.0	28	12.3	43	8.2
Other	7	2.3	12	5.3	19	3.6
Employment Status						
Hourly	271	88.9	210	87.9	481	88.6
Salaried	34	11.1	28	11.7	62	11.4

Supervise Others						
Yes	26	8.0	26	10.9	52	9.5
No	281	86.7	213	89.1	494	90.5

In addition, the subjects were requested to indicate whether they had received lean production training. This question was followed by the identification of seven categories of potential lean training received as well as an open-ended item to identify other training received related to lean production. Table 3.3 provides an overview of the results.

Table 3.3

Total and Percent Participation in Lean Training by Facility and Total

	Midwest Plant		**Southeast Plant**		**Total**	
Training Area	**Total**	**Percent**	**Total**	**Percent**	**Total**	**Percent**
Lean Training	271	88.9	134	56.3	405	72.6
5 S	214	70.4	111	46.8	325	58.6
7 Forms of Waste	129	42.4	60	25.3	189	33.8
Introduction to Lean Production	211	69.4	69	29.1	280	49.3
People Focused Factory	196	64.5	47	19.8	243	42.2
Factory Simulation	143	47.0	73	31.1	216	39.1
Team Building	168	55.3	55	23.3	223	39.3
Problem Solving	158	52.0	69	29.2	227	40.6
Other Related Training	35	11.6	12	5.1	47	8.9

Measurement of Variables

In the following section, a description of the measurement of the central variables is presented. The literature examining the relationship between people and technical systems with performance and work-related attitudes has included a variety of measures. As discussed earlier, little of this literature was conducted in a lean production context. Therefore, this research uses measures and constructs when deemed applicable from the existing literature and has specified and constructed suitable measures and constructs at other times when determined appropriate.

The data sources for this dissertation were based on a combination of sources. The data collection instruments include an attitude survey, an assessment of the technical elements of lean production, an assessment of perceived department effectiveness, archival department performance, and interview data. Table 3.4 provides an overview of the variables, assessment instruments and items on the surveys linking the independent, mediating and dependent variables. The hypotheses testing is based on 61 departments across the two sites that participated in this study (N=61).

Table 3.4

Variables, Assessment Instruments, and Items on the Surveys

Variable	Assessment Instrument	Items on Survey
Independent Variable:	**Appendix A: Perceptions Regarding the Implementation of Lean Production**	
People Systems		
	Supervisory behaviors	1-14
	Management support	15-22
	Cooperative union management relations	23-29
	Developmental focus	50-56
	Managing change	65-69

Teamwork	70-76
Involvement/psychological participation	77-80
Process focus	81-88
Proactive problem solving	89-95
Workplace trust	96-103
Workplace bonding	104-109
Workplace bridging	110-120
Conflict resolution climate	121-129
Lean training	Page 12

Independent Variable: **Appendix B: Implementation of lean production**

Technical Systems

Flow Manufacturing:	
Manufacturing is organized by value stream	1
Takt time	2
Employee Environment:	
Cross-functions/multi-skills/certification	4
Natural work group structure & support	5
Workplace Organization:	
Clear/clean/organized & maintain the production area & office	6
Visual controls	7
Quality:	
Inspection & test	8
Process capability	9

Independent Variable: **Appendix B: Implementation of lean production**

Technical Systems

Operational Availability	
Owner operator	12
Quick set-up	13
Material Movement:	
Container right sizing & supporting the operator	14
Internal material delivery	15

Mediating Variable:	**Appendix B: Implementation of Lean Production**	
Integration		
	Employee Environment and Involvement:	
	People focused practices	3
	Suggestion system	16
	Quality:	
	Detect, solve & prevent quality problems	10
	Operational Availability:	
	Continuous improvement	11
Dependent Variable:	**Appendix A: Perceptions Regarding the Implementation of Lean Production**	
Work-Related Attitudes		
	Commitment to the lean production strategy	30-34
	Job satisfaction	35-39
	Perceived learning environment	40-49
	Team efficacy	130-140
Dependent Variable:	**Appendix A: Perceptions Regarding the Implementation of Lean Production**	
Perceived Performance	Perceived department performance	55-64
	Appendix C: Perceptions Regarding the Effects of the Implementation of Lean Production	1-12

Independent Variables

The two independent variables include the technical systems of lean production and the people systems of lean production. The people elements of lean production are measured by a questionnaire. The independent variables assessed in the questionnaire include the following constructs: (1) Supervisory practices; (2) Management support; (3)

Cooperative union-management relations; (4) Developmental focus; (5) Managing change; (6) Teamwork; (7) Involvement/psychological involvement; (8) Process focus; (9) Proactive problem solving; (10) Workplace trust; (11) Workplace bonding; (12) Workplace bridging; (13) Conflict resolution climate; and (14) Lean training. The scales are all five-point items except lean training, which is a yes/no response to specific lean training items and the results are presented above in Table 3.3. Table 3.5 provides a list of the independent, mediating and dependent variables and the operational constructs for each variable.

The assessment instrument entitled Perceptions Regarding the Implementation of Lean Production was completed by 261 employees from the facility located in the Southeast and by 324 employees from the plant located in the Midwest for a total of 585 completed surveys across the two facilities. This survey is located in Appendix A. The survey was designed to collect data related to the independent variables associated with the people systems of lean production.

The development of the Perceptions Regarding the Implementation of Lean Production survey resulted from a number of different sources (Cook, 1981). As stated above, some of the measures and items were based on existing instruments, while others were developed specifically for this study, while yet others were amended to fit the needs of this research design. Each of the constructs, source or sources is provided in Table 3.6 located in Appendix E. Table 3.7 provides a summary of the assessment instrument, data source, and number of respondents.

Table 3.5: Independent, Mediating, Dependent Variables, and Operational Constructs

Independent Variables	Mediating Variables	Dependent Variables
Technical Elements of Lean Production	*Integration Elements of Lean Production*	*Department Effectiveness/Performance*
❑ Manufacturing org. by value stream	❑ Standardized work (PFP) performed by shop floor people and focused on continuous improvement efforts	❑ Cost
❑ Manage by takt time	❑ Teams adjust work assignments to match takt time	❑ Productivity
❑ Operators Cross-functional & multi-skilled, certification	❑ Problem solving in place and consistently followed	❑ Quality
❑ Team structure and support	❑ Problem solving has become a change methodology process	❑ Delivery
❑ 5 S (clear, clean, etc.)		❑ Suggestions
❑ Visual control		*Individual Perceptions*
❑ Inspection		❑ Commitment to lean strategy
❑ Error proofing		❑ Job satisfaction
❑ Process capability		❑ Perceived learning environment
❑ Operator monitor, clean, & performs minor maint		❑ Perceived department performance
❑ Quick set-up		❑ Team efficacy
❑ Container right sizing		
❑ Line side delivery, small lots, will pull signal		

Table 3.5: Independent, Mediating, Dependent Variables, and Operational Constructs (continued)

Independent Variables	Mediating Variables	Dependent Variables
People Elements of Lean Production		
❑ Supervisory behaviors		
❑ Management support		
❑ Cooperative union-management relations		
❑ Developmental focus		
❑ Managing change		
❑ Teamwork		
❑ Involvement/psychological participation		
❑ Process focus		
❑ Proactive problem solving		
❑ Workplace trust		
❑ Workplace bonding		
❑ Workplace bridging		
❑ Conflict resolution climate		
❑ Lean training		

Table 3.7

Assessment Instrument, Data Source, Number of Respondents

Assessment Instrument	Data Source	Respondents
Perceptions Regarding the Implementation of Lean Production (Appendix A)	Stratified Sample of Employees	585
Implementation of Lean Production (Appendix B)	Superintendents	12
Perceptions Regarding the Effects of the Implementation of Lean Production (Appendix C)	Supervisors Superintendents	71 12
Interview Protocol (Appendix D)	Superintendents	12
Department Performance Data	Archival Data	2

A second instrument was adapted to assess the technical elements of lean production entitled The Implementation of Lean Production, which is contained in Appendix B. This instrument was designed and administered to assess the degree to which the technical elements of lean production had been implemented in each department. That is, this measurement instrument quantifies the extent to which each department has become a lean producer. The instrument was administered to the superintendent for each department, which resulted in each superintendent completing an assessment instrument for more than one department. The number of departments assessed by each superintendent varied between two and eight departments.

The technical systems of lean production have been defined in various forms by a number of different sources. However, the key elements of lean production are based on the Toyota Production System. The document that provides the basis for this assessment instrument was used by the participating organizations to assess the gap between the current state and their future vision for lean production, which likewise is based on the Toyota Production System. Other analytic instruments were considered for this purpose. The existing internal assessment instrument was adopted because of its high quality and the familiarity of the subjects with the terms on the lean assessment instrument.

The technical elements of lean production measured include the following lean production categories: (1) Flow manufacturing (manufacturing is organized by value stream and takt time); (2) Employee environment and involvement (cross functional/multi-skilled certification, and natural workgroup structure and support); (3) Workplace organization (clear, clean, organized and maintain work area, and visual controls); (4) Quality (inspection and testing, process capability,); (5) Operational availability (owner operator and quick set-up); and, (6) Material movement (container right sizing, supporting the operator, and internal material delivery). The gap analysis developed by this organization is a plant assessment tool, and as such, was adjusted for this study to focus at the department level. The response scales are four-point, with a score of 1 being the least lean.

Mediating Variables

There are four measures of the integration of the technical and people systems of lean production. The premise is that to fully maximize the full potential of lean production, an organization must have fully developed and implemented both the technical and people aspects of lean, and that these sub-systems of lean production are fully integrated at the level in which value is added to the product. While the integration of these systems needs to occur at other levels of the organizations, this study focuses on integration at the shop floor. The integration variable will be measured by assessing the existence of the following practices: (1) Standardized work is performed by shop floor people and focused on continuous improvement; (2) Teams adjust work assignments to match takt time; (3) Problem solving is in place and consistently followed; and (4) Problem solving has become a change methodology process. The integration questions are located within the lean assessment instrument (questions 3, 10, 16 and 11) and is located in Appendix B. Accordingly, the integration items were also completed by the superintendent level at each location.

Dependent Variables

In this study the dependent variables fall into three categories. The first category is actual department performance. The request by this researcher was to identify common measures for cost, quality, productivity, delivery and suggestion data. These measurement categories are common measures within a manufacturing setting. Plant personnel and the researcher worked through numerous measures until the best available data was obtained. The primary challenge in this aspect of the study was in obtaining common data at the department level. Manufacturing organizations track and retain vast amounts of data. In fact, it is not unusual for manufacturing organizations to track and retain data that is not used for further analysis or for data based decision making.

This performance data is based on data already tracked by the participating departments. Given the difficulty in finding common measures across departments and plants making different products, the supervisory perceptions of performance resulting from the implementation of lean production will be used to bolster this aspect of the study. The department performance data was provided for the end of month and year to date performance for February, May and August 1999.

In the end, the following data were provided. The actual number and percent of suggestions were made available for each department. Up-time by department was also provided. This is an efficiency measure that indicates the amount of time that all of the equipment in any given department is available. Actual downtime for assembly areas was also provided. This is a measure of similar meaning to up-time for manufacturing operations. Performance-to-plan was also provided. This performance measure provides actual numbers of products produced compared with performance objectives. The plant was unwilling to share cost or quality data due to public disclosure concerns.

A third data collection tool was developed to collect input from supervisors and superintendents regarding the consequences of the implementation of lean production on department effectiveness. This third assessment instrument is entitled Perceptions Regarding the Effects of the Implementation of Lean Production. The goals for this instrument were twofold. One, it was designed to obtain the perceptions of supervisors and superintendents related to the implementation of lean production and its impact on department performance. Two, this assessment instrument was designed to augment archival performance data from the same departments. This two-part approach (i.e., perceptions of department performance and actual performance) was developed to offset potential problems that often occur in obtaining accurate and useful performance data at the department level. This instrument consists of 12 survey questions with seven-point response scales and is located in Appendix C.

In addition, department work-related attitudes are measured as dependent variables. These work-related attitudes include the following: (1) Commitment to the lean production strategy; (2) Job satisfaction; (3) Perceived learning environment; and, (4) Team efficacy. These constructs are used to assess differences in work-related attitudes of employees in a technical approach to lean production and in contrast with an integrated approach to lean production. This data was collected as part of the larger attitude survey. That is, Perceptions Regarding the Implementation of Lean Production located in Appendix A. In total, this survey consists of 10 demographic questions, one open ended question, and 140 survey items across18 constructs.

Covariate

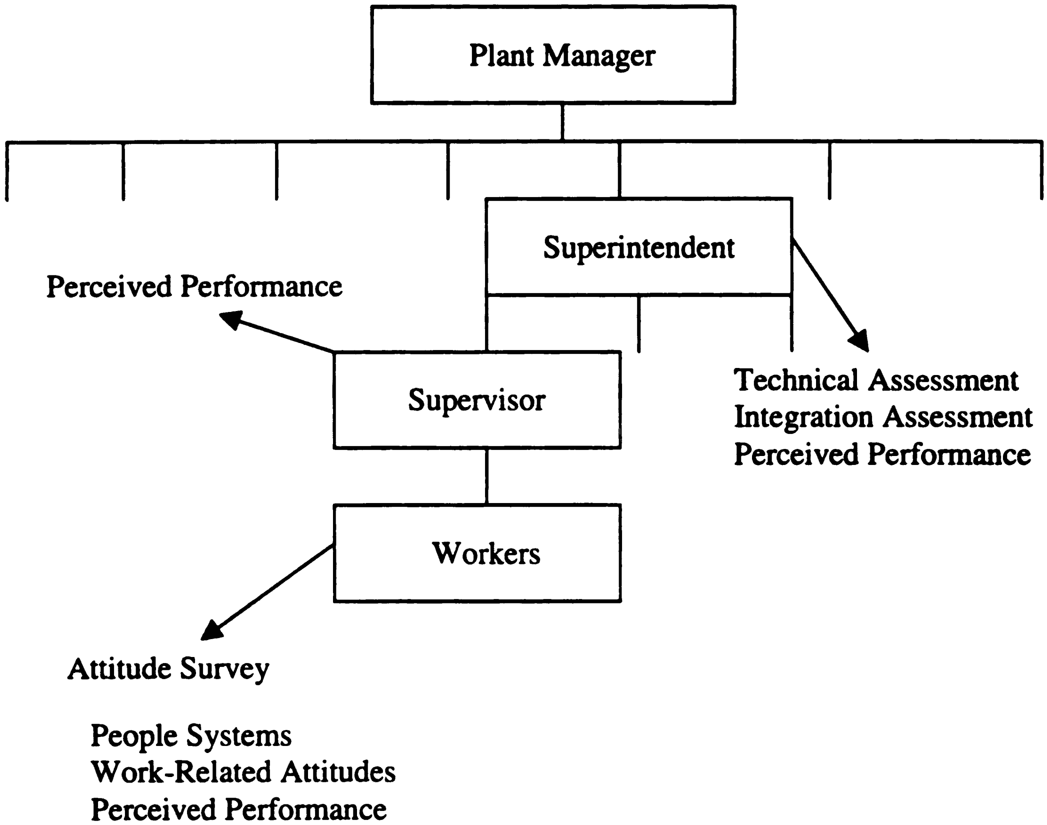
Department size has been identified as a covariate for this study. Department size is often cited as potential confounds in organizational studies at the department level. As such, data regarding department size has been identified and its potential impact on the dependent variables will be examined and controlled for.

Organization and Assessment Structure

In summary, workers at the shop floor level completed the attitude survey Perceptions Regarding the Implementation of Lean Production, which contains items related to people systems, work-related attitudes, and perceived performance (see Appendix A). The supervisor level completed perceived performance survey entitled Perceptions Regarding the Effects of the Implementation of Lean Production (see Appendix C). The superintendent level completed the technical assessment instrument entitled Implementation of Lean Production (see Appendix B), completed the integration assessment instrument (also see Appendix B), and the perceived performance assessment instrument entitled Perceptions Regarding the Effects of the Implementation of Lean Production (see Appendix C). Figure 3.1 provides an overview of the level of personnel to complete each of the assessment instruments.

Figure 3.1

Organization and Assessment Structure



Data Collection Procedures

This section describes the data collection procedure used in this study. The methodology encompasses four phases: (1) Identifying the sample; (2) Testing the assessment instruments; (3) Collecting quantitative data; and, (4) Collecting qualitative data.

Phase I: Identifying the Sample

A model and description of approaches to the diffusion of lean production was reviewed with key leaders from the headquarters of the sponsoring organization in this study. (See Chapter 2, Figure 2.1.) Based on this definition and framework, these key leaders were asked to identify plants that best represented the integrated approach to lean production and the technical approach to lean production. These key leaders from the participating organization included both human resource and manufacturing leaders. These leaders identified one assembly plant (located in Belgium) and one component plant (located in North America) that best represented the integrated approach. These leaders also identified one assembly plant (located in Germany) and one component plant (located in the U.S.) that best represented the technology focused approach to lean production. While the larger research design includes international comparisons, this dissertation is focused only on the component plants located in the U.S.

Key leaders were then interviewed and provided with the same definitions and model of alternative approaches to the diffusion of lean production within the U.S. component plants and requested to identify at least 30 departments to participate in this study. And, that at least 10 of these departments should represent the plants best and worst lean producing departments within their respective plants. A collection of 3-5 representatives from each location identified the departments to participate in this study based on the model and definitions. Neither plant revealed which of the 10 plus departments represented the best and worst lean production work areas.

The plant located in the Midwest identified 31 departments to participate in the research and the plant located in the Southeast identified 30 departments for a total of 61 participating departments. The departments were drawn from assembly and component operations at both plant locations.

Phase II: Testing the Assessment Instruments

The attitude survey entitled Perceptions Regarding the Implementation of Lean Production (see Appendix A) was tested with a number of different groups. First, the survey was reviewed with three university faculty members. Their feedback was used to amend and improve the questionnaire. Next, a focus group of 3-5 internal experts was held to review the questionnaire at each location and the survey was further refined. The survey was then tested with two faculty members and one student before testing it with a group of 3-5 employees from each facility. During this phase, each test subject completed the survey and identified any items that were confusing or redundant. Pilot testing the survey suggested that the questionnaire could be completed within 30 minutes. Finally, the questionnaire was tested with a cross-functional group. The cross-functional group included: (1) a division labor relations manager; (2) four union representatives; (3) two training and organizational change employees; (3) two production supervisors; (4) a superintendent; (5) a quality control manager; (6) two lean production experts; and, (7) two plant managers. The survey was then administered.

As stated above, the Lean Production assessment instrument (see Appendix B) is based on an internal gap assessment. The original lean gap assessment device is a plant-wide instrument. This instrument was adjusted to assess the degree of lean implementation at the department level. The Lean Production assessment instrument was tested with a manager of lean production implementation, an organizational change and training manager and the researcher. The amended instrument was then administered.

The Perceptions Regarding the Effects of the Implementation of Lean Production assessment instrument (see Appendix C) was developed with the advice and counsel of two faculty members. This assessment instrument was reviewed with a manager of organizational change and training from the facility located in the Midwest and the manager of lean production and employee development located in the Southeast. The instrument was pilot tested with three university associates. The assessment instrument was then administered.

Phase III: Collecting Quantitative Data

The research site located in the Southeast elected to administer the attitude survey on site. The hourly workforce completed the survey in a large conference room located near the production floor. Each survey was coded for each department to ensure accurate administration and analysis. Some of the surveys were completed at other sessions in other conference rooms for specific employees (e.g., engineers, supervisors, and superintendents). This adjustment to survey administration was adopted for the convenience of the employees and to encourage subject participation. This type of flexibility is more difficult in the case of production workers. Also, a few employees completed the survey at their desks when the employees were able to find the time. The questionnaires were administered by the researcher. The total number of surveys returned was 261, which represented a capture rate of 40% for the targeted departments.

The research site located in the Midwest decided to administer the survey by mailing the questionnaire to the employees' homes. The surveys were coded by department for those departments that participated in the full research design. The total number of surveys returned was 228. This represented a capture rate of 12% of the plant population. As a result of the limited capture rate, additional efforts were made to administer the survey. These efforts included going to each of the targeted departments and requesting that those employees that did not return the survey to take time at their team meetings to complete the survey. Similar efforts were made to increase the number of surveys completed by salaried employees. These efforts resulted in an additional 96 surveys being returned, increasing the total number of surveys returned to 324 and a capture rate of 17% of the plant population.

Phase IV: Collecting Qualitative Data

Interviews with key leaders at each facility occurred in June 1999. The interview data are used to provide insight and understanding. The interviews were conducted during the same period in which the attitude surveys were being collected. The interviews were conducted with the following positions at each location: (1) Plant managers; (2) Human resource managers; (3) Superintendents; (4) Union officials; and (5) People identified as internal experts in the area of lean production. The interview protocol is located in Appendix D.

This research design is a cross-sectional study and as such data were collected as close to one point in time as allowed by the participating organizations. The survey of the employee attitudes was conducted during June of 1999. The employee attitude instrument was completed during June as a result of labor negotiation for the unionized workforce. Both plant management and the union required that this data be collected prior to July 1999. Department performance data is based on actual performance tracked as a required on-going plant activity for the end of month performance and year-to-date for the periods of February, May and August 1999. For the plant located in the Midwest, the supervisors and superintendents completed the assessment of perceived performance during the month of October 1999 and the superintendent level completed the technical lean production and integration instrument at the same time. As a result of internal complications, the plant located in the Southeast was not able to provide this data until January 2000.

Data Analysis Procedures

Multiple regression analysis and factor analysis will be used in this study. Multiple regression analysis will be employed to estimate the model of the determinants of the production work system. The determinants will include variables that define the technical and people systems as well as the integration variables. The analysis of the determinants will be assessed at one point and time and is thus a cross-sectional study. Data at the department level will be analyzed to provide comparisons of the technical system, people system and integration variables. Factor analysis will be used to evaluate and possibly reduce the number of survey constructs and items.

Factor Analysis

Factor analysis will be conducted on the attitude survey entitled Perceptions Regarding the Implementation of Lean Production. Factor analysis is used to discover which variables in a data set form coherent subgroups (factors) that are relatively independent from one another (Tabachnick, 1983: 372). The specific purpose for factor analysis in this study will be to reduce the number of items and variables to a smaller number of clusters while retaining maximum spread among each of the survey constructs. While each of the survey items have been reviewed extensively by numerous experts, tested and discussed, factor analysis will provide additional content validity for the survey constructs. In short, exploratory factor analysis will be conducted to consolidate the number variables and items within the survey. The following steps are followed in conducting the factor analysis: (1) Select and measure of the variables; (2) Prepare the correlation matrix; (3) Determine the number of factors to be considered; (4) Extract the factors from the correlation matrix; (5) If needed, rotate the factors to increase interpretability; and, (6) Interpret the results (Tabachnick, 1983: 373).

Hierarchical Regression

Hierarchical regression analysis permits assessment of whether each variable significantly predicts the dependent variable with the variance due to other independent variables controlled (Cohen, 1983). Or put differently, hierarchical regression allows the researcher to determine how to enter the independent variables (Tabachnick, 1983).

Hierarchical regression will be used to test the relationships in the following hypotheses. In each of these hypotheses department size will be controlled for in advance of entering the independent variables. The proposed analysis that ensues will use three different but related analytical approaches. Approach 1 will be used for hypothesis 1 through hypothesis 5 and will proceed along the following steps (See Table 3.8 for a review of the hypotheses):

Step 1: Department size will be entered first as control variables.

Step 2: For hypotheses 1 and 2 technical systems will be entered second to investigate the degree of association with department performance for hypothesis 1 and the degree of association with perceived performance for hypothesis 2.

These same steps will be followed in examining the degree of association between people systems and the dependent variables.

Step 1: Department size will be entered first as a control variable.

Step 2: People systems will be entered second to investigate the degree of association with department performance (hypothesis 3), perceived performance (hypothesis 4) and with work-related attitudes (hypothesis 5).

The research model for hypotheses 1 through 5 is as follows:

Figure 3.2: Research Diagram for Hypothesis 1 through Hypothesis 5

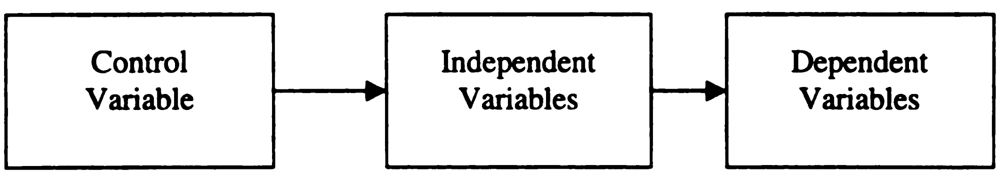


Table 3.8

Research Hypotheses

H1	Technical Systems of lean production are positively and significantly related to department performance.
H2	Technical Systems of lean production are positively and significantly related to perceived department effectiveness.
H3	People Systems of lean production are positively and significantly related to department performance.
H4	People Systems of lean production are positively and significantly related to perceived department performance.
H5	People Systems of lean production are positively and significantly related to work-related attitudes.
H6	The consonance between the technical systems and people systems in lean production are positively and significantly related to department performance.
H7	The consonance between the technical systems and people systems in lean production are positively and significantly related to perceived performance.
H8	The consonance between the technical systems and people systems in lean production are positively and significantly related to work-related attitudes.
H9	The relationship of the technical systems and people systems with department performance will be partially mediated by integration practices.
H10	The relationship of the technical systems and people systems with perceived performance will be partially mediated by the integration practices.
H11	The relationship of the technical systems and people systems with work-related attitudes will be partially mediated by the integration practices.

Hierarchical regression is also called moderated regression (Stone, 1984). The term moderator variable refers to an independent variable that potentially enters into interaction with "predictor" variables, while having a negligible correlation with the criterion itself (Cohen, 1983; Stone, 1984). The order of entry of the independent variables becomes very important in studying moderating effects (Stone, 1984). In this research regarding the consonance hypothesis, the proposition is that the people systems must be in harmony with the technical system to maximize the effectiveness of the work system. That is, the premise of the consonance hypothesis within the STS literature proposes that organizations will perform effectively only to the extent that their social structures are compatible with the requirements and dictates of the technical systems. The second approach to be used in this research for hypothesis 6 through hypothesis 8 will follow the ensuing steps:

Step 1: Department size will be entered first as a control variable.

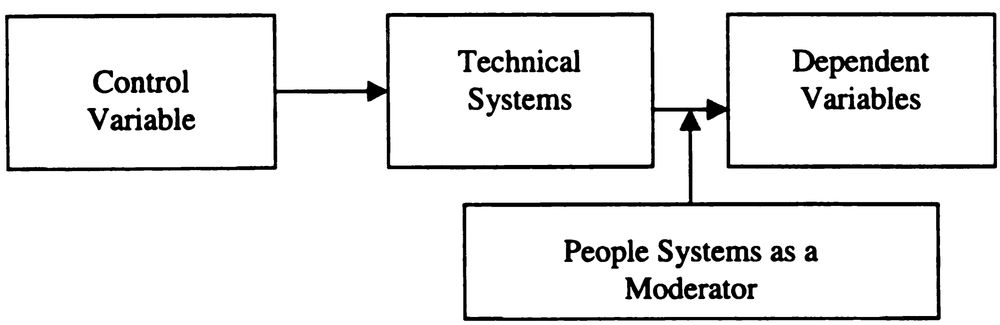
Step 2: Technical systems and people systems are entered second and simultaneously.

Step 3: Next, an interaction effect is assessed by multiplying technical systems and people systems and entered third to investigate any moderating effect of people systems on the dependent variables.

The research diagram for hypotheses 6 through 8 is as follows:

Figure 3.3

Research Diagram for Hypothesis 6 through Hypothesis 8



The last three hypotheses build further upon the analyses proposed thus far. Hypotheses 9 through 11 are designed to test for the mediating affect of the integration variable. The ensuring steps will be followed for hypotheses 9 through 11:

Step 1: Department size will be entered first as a control variable.

Step 2: Technical systems and people systems will be entered simultaneously.

Step 3: Integration will be entered last. My entering the integration variable last will allow the examination of any additional variance that can be explained by the integration activities.

After completing this series of steps, the order of entering the technical and people systems variables and the integration variables are reversed. By reversing the order of entry allows evaluation of any additional variance explained by the mediating variable. The following steps are followed:

Step 4: Department size will be entered first as a control variable.

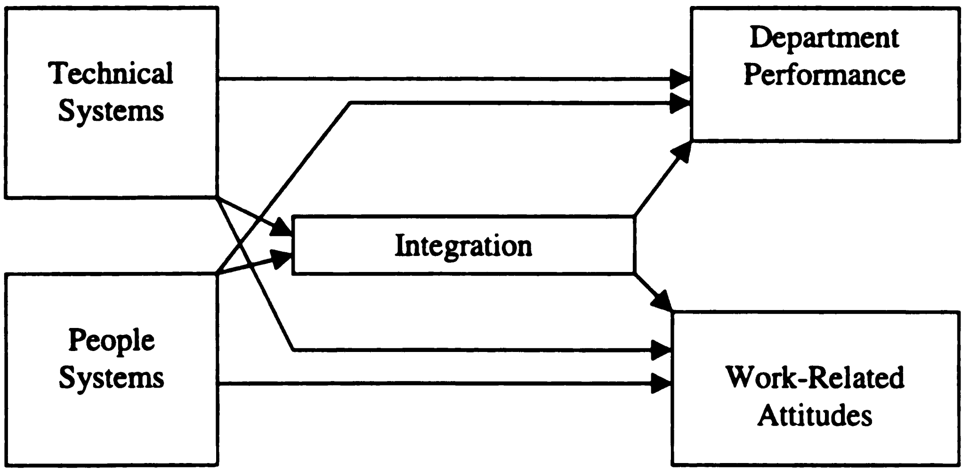
Step 5: The integration variable is entered next.

Step 6: And, in this phase technical and people systems will be entered simultaneously in the last step.

The research model for hypotheses 9, 10 and 11 is as follows:

Figure 3.4

Research Diagram for Hypothesis 9 through Hypothesis 11



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CHAPTER FOUR

RESULTS

In this chapter, the results of each hypothesis are presented. The chapter also includes descriptive statistics, correlation analysis, and factor analysis as well as a summary of the research findings.

Descriptive Statistics and Correlation Analysis

In this section, the descriptive statistics and correlation analyses will be presented for each of the assessment instruments. The assessment instruments include: 1) Perceptions Regarding the Implementation of Lean Production, which includes the independent people systems variables (e.g., supervisory behaviors and management support) as well as the dependent work-related attitude variables (e.g., team efficacy and commitment to lean production strategy); 2) The Implementation of Lean Production assessment instrument, which includes the technical systems assessment questions and the integration items; and, 3) Perceptions Regarding the Effectiveness of the Implementation of Lean Production. This section also provides a correlation analyses of the independent variables with the dependent variables.

Perceptions Regarding the Implementation of Lean Production

The mean, standard deviations, and correlations for each scale are presented in Table 4.1. (The people systems assessment instrument is located in Appendix A.) The reliability coefficients (alphas) are presented on the diagonals. The people systems scales were created in a two step process. First, the data was aggregated at the individual level. Second, mean responses were created at the work unit level. All questions are based on a five-point scale, except team efficacy (item 18), which is based on a seven-point scale.

The measure for lean training is calculated based on a series of yes/no (ordinal) responses for specific lean training participated in by each survey respondent. Mean responses were then created for each department. There are eight lean training questions in total. Hence, the range of responses for any respondent varies between zero and eight (0-8). There is no reliability coefficient for lean training (item 19).

Table 4.1 shows that the majority of the scales are significantly correlated. Of the 171 possible correlations, 139 are correlated at the .01 level, 8 are correlated at the .05 level, and 24 are not correlated. The table shows that lean training is not significantly correlated with any of the scales, except for a -.26 correlation with workplace bridging at the .05 level. The table also shows that the reliability coefficients (alphas) range from the high of .96 for supervisory behaviors to a low of .74 for both cooperative union management behaviors and for commitment to lean strategy. The average reliability for the entire instrument is .85.

Table 4.1

Descriptive Statistics, Correlations and Reliability Coefficients for People Systems of Lean Production

Variable	M	SD	1	2	3	4	5	6	7	8
1. Supervisory behavior	3.10	.6159	(.96)							
2. Management support	2.52	.5527	.56**	(.92)						
3. Cooperative Union Management Relations	3.10	.4992	.34**	.63**	(.74)					
4. Commitment to lean strategy	3.27	.3928	.29*	.51**	.33*	(.74)				
5. Job satisfaction	2.93	.5816	.67**	.69**	.38**	.49**	(.81)			
6. Perceived learning environment	2.98	.4471	.68**	.62**	.39**	.64**	.67**	(.87)		
7. Developmental focus	2.95	.4503	.74**	.71**	.52**	.39**	.66**	.62**	(.79)	
8. Perceived team performance	3.24	.4651	.37**	.71**	.62**	.58**	.64**	.55**	.59**	(.92)
9. Managing change	2.74	.5167	.55**	.67**	.65**	.51**	.52**	.68**	.68**	.65**
10. Teamwork	2.92	.5211	.42**	.57**	.40**	.41**	.36**	.59**	.48**	.41**
11. Involvement/ psychological participation	2.58	.6411	.63**	.50**	.15	.44**	.48**	.66**	.61**	.36**
12. Process focus	3.25	.4893	.48**	.65**	.51**	.43**	.55**	.58**	.56**	.61**
13. Proactive Problem solving	2.51	.5363	.52**	.65**	.51**	.49**	.47**	.65**	.63**	.47**
14. Workplace trust	2.58	.4618	.52**	.61**	.44**	.26*	.53**	.52**	.53**	.38**
15. Workplace bonding	2.96	.4645	.59**	.38**	.29*	.35**	.44**	.60**	.51**	.29*
16. Workplace bridging	2.68	.4678	.55**	.69**	.62**	.29*	.62**	.56**	.76**	.58**
17. Conflict resolution climate	2.91	.4731	.78**	.61**	.48**	.34**	.56**	.57**	.73**	.48**
18. Team efficacy	4.65	.8607	.16	.36**	.27*	.10	.13	.25*	.24	.28*
19. Lean training	4.08	1.57	.10	-.07	-.14	.08	-.06	.15	.06	-.13

N = 66 departments listwise.

*Correlation is significant at the .05 level (2-tailed).
**Correlation is significant at the .01 level (2-tailed).

Internal consistency reliability coefficients (alphas) appear in parentheses along the main diagonal. Lean training was based on a series of yes/no (ordinal) responses and as such there is no reliability coefficient.

Table 4.1 (Continued)

Descriptive Statistics, Correlations and Reliability Coefficients for People Systems of Lean Production

Variable	9	10	11	12	13	14	15	16	17	18
1. Supervisory behavior										
2. Management support										
3. Cooperative Union Management Relations										
4. Commitment to lean strategy										
5. Job satisfaction										
6. Perceived learning environment										
7. Developmental focus										
8. Perceived team performance										
9. Managing change	(.84)									
10. Teamwork	.56**	(.86)								
11. Involvement/ psychological participation	.54**	.65**	(.86)							
12. Process focus	.69**	.71**	.55**	(.87)						
13. Proactive Problem solving	.69**	.82**	.70**	.78**	(.93)					
14. Workplace trust	.57**	.55**	.47**	.53**	.60**	(.77)				
15. Workplace bonding	.47**	.67**	.66**	.47**	.60**	.69**	(.87)			
16. Workplace bridging	.65**	.63**	.54**	.65**	.74**	.67**	.57**	(.86)		
17. Conflict resolution climate	.57**	.51**	.65**	.48**	.60**	.43**	.53**	.68**	(.81)	
18. Team efficacy	.34**	.54**	.20	.59**	.47**	.54**	.36**	.33**	.09	(.95)
19. Lean Training	.15	.12	.12	.23	.05	-.03	.08	-.26*	-.13	.17

N = 66 departments listwise.

*Correlation is significant at the .05 level (2-tailed).
**Correlation is significant at the .01 level (2-tailed).

Internal consistency reliability coefficients (alphas) appear in parentheses along the main diagonal. Lean training was based on a series of yes/no (ordinal) responses and as such there is no reliability coefficient.

Implementation of the Technical Systems of Lean Production

The mean, standard deviation, and correlations for each item are presented in Table 4.2. (The technical systems assessment instrument is located in Appendix B.) The reliability coefficient (alphas) for the technical systems assessment items is .91. The reliability coefficient (alphas) for the integration items is .82. The integration questions include items 3, 10, 11, and 16. All other questions are technical systems assessment items. All questions on this instrument are four-point scales. Questions 9 and 13 were eliminated from this analysis because of a low response rate. Follow-up questions of internal plant experts revealed that item 9 regarding process capability achieved a low response rate because the respondents found the item to be confusing. In the case of item 13 regarding quick set-up, this technical system is not used extensively in some departments resulting a low response rate.

Table 4.2 shows that most of the items are significantly correlated at the .01 level. Of the 91 possible correlations, 86 are significantly correlated at the .01 level, two items are correlated at the .05 level, and two are not significantly correlated. Of the ten remaining technical assessment questions, the reliability coefficient (alpha) is .92.

Table 4.2

Descriptive Statistics and Correlations for the Technical Systems Assessment

Variable/Item	M	SD	1	2	3	4	5	6	7	8	10	11	12	14	15
1. Organized value stream	3.05	1.08													
2. Takt time	2.95	1.13	.73**												
3. People focused practices	2.45	1.03	.39**	.79**											
4. Cross function & skills	2.86	1.05	.45**	.71**	.77**										
5. Natural work groups	2.61	1.19	.46**	.74**	.82**	.88**									
6. Clear, clean, organized & maintained	2.63	.89	.35**	.61**	.74**	.69**	.71**								
7. Visual controls	2.58	.88	.37**	.51**	.60**	.75**	.67**	.59**							
8. Inspection & test	2.78	.68	.59**	.44**	.40**	.50**	.39**	.09	.31*						
10. Detect, solve & prevent	2.12	.83	.61**	.47**	.34**	.48**	.26*	.13	.28*	.70**					
11.Continuous improvement	2.44	.86	.60**	.47**	.43**	.44**	.37**	.42**	.35**	.53**	.61**				
12. Owner operator	2.59	.86	.63**	.52**	.42**	.43**	.43**	.51**	.47**	.43**	.49**	.69**			
14. Container right sizing & operator support	2.47	.86	.52**	.45**	.51**	.56**	.43**	.41**	.38**	.60**	.65**	.58**	.61**		
15. Internal material delivery	2.71	.65	.40**	.49**	.49**	.66**	.51**	.44**	.57**	.41**	.45**	.39**	.19	.56**	
16. Suggestion system	2.71	.89	.49**	.66**	.77**	.70**	.67**	.60**	.48**	.47**	.54**	.62**	.50**	.65**	.54**

Where as:

Range of 54 to 59 exclude pairwise

Coefficient alpha for technical assessment items = .92

Coefficient alpha for integration items =.82.

** Correlation is significant at the .01 level (2-tailed)

* Correlation is significant at the .05 level (2-tailed)

Lean Production and Perceived Effectiveness

The Perceptions Regarding the Effects of the Implementation of Lean Production assessment instrument was designed to measure the perceived effectiveness from the supervisor and superintendent perspective. The mean, standard deviation and correlation for each item is presented in Table 4.3. The internal reliability coefficient (alpha) is .97. All questions in the instrument are seven-point scales. All items are statistically significant at the .01 level.

A total of 51 valid effectiveness surveys were completed by 14 superintendents across the two facilities. On average, each superintendent completed 3.6 surveys. A total of 70 supervisors completed 70 valid surveys across the two plants. Each survey was completed at the department and shift level, which is referred to throughout this analysis as department.

Table 4.3: Means, Standard Deviations, and Correlations

Of Perceived Effectiveness of Lean Production as Rated by Supervisors and Superintendents

Variable/Items	M	SD	1	2	3	4	5	6	7	8	9	10	11
1. Serving our customers	4.02	1.59											
2. Continuous improvement	4.14	1.66	.90**										
3. Improving quality	4.41	1.84	.82**	.87**									
4. Reducing costs	3.91	1.60	.83**	.83**	.77**								
5. Elimination of waste	3.86	1.61	.76**	.80**	.79**	.82**							
6. Improving safety	4.35	1.83	.68**	.74**	.73**	.69**	.64**						
7. Improving ergonomics	4.45	1.80	.67**	.75**	.77**	.70**	.70**	.88**					
8. Generating suggestions	4.15	1.72	.78**	.74**	.71**	.78**	.68**	.77**	.74**				
9. Implement suggestions	3.91	1.69	.75**	.70**	.68**	.76**	.64**	.74**	.73**	.89**			
10. Improve performance	4.21	1.76	.91**	.82**	.69**	.83**	.76**	.66**	.61**	.77**	.79**		
11. Solving problems	4.07	1.74	.77**	.81**	.73**	.73**	.76**	.76**	.70**	.75**	.77**	.83**	
12. Becoming more integrated and cohesive	4.12	1.71	.82**	.84**	.79**	.81**	.81**	.70**	.74**	.75**	.75**	.84**	.86**

Where as:

Reliability coefficient (alpha) = .97.
N=85. Seven-point scale.
**Correlation is significant at the .01 level (2-tailed).

Correlation of Independent and Dependent Variables

Table 4.4 provides the correlations of the independent and dependent variables. Bivariate correlation was used to compare the variables. Items 1 through 13 are scales based on 533 valid survey respondents as well as the work-related attitudes (commitment to lean strategy, job satisfaction, learning environment, and team efficacy), and perceived department performance. Mean effectiveness (MGT) is based on 51 effectiveness surveys completed by 14 superintendents and 70 supervisor completed surveys for 70 different departments across the two plants. The effectiveness surveys completed by the supervisors and superintendents were averaged for each department and shift. People systems composite is a scale based on items 1 through 13 in Table 4.4. Lean training is based on eight yes/no questions on the survey. Each of the yes responses was summed to provide an overall lean training measurement at the individual level. Hence, the range for individual responses to lean training is 0-8.

Mean effectiveness of the supervisor and superintendent level (MGT) is positively and significantly correlated with lean training, integration and the technical systems of lean production at the .05 level. In contrast, developmental focus and workplace bridging is negatively and significantly correlated at the .01 level. Each of the following work-related attitudes including commitment to lean strategy (CLS), job satisfaction (JS), learning environment (LE), and perceived department performance (PTP) is positively and significantly associated with each of the people system scales (items 1-13) and with people systems composite at the .05 level. Team efficacy is statistically and positively associated at the .05 with these same measures, except for supervisory behaviors, involvement psychology, and conflict resolution, which are not correlated. Lean training is positively and significantly correlated only with the mean effectiveness of the supervisor and superintendent level (MGT), integration is positively and significantly correlated with mean effectiveness (MGT) at the .05 level and is statistically and negatively associated with job satisfaction (JS) at the .01 level. Technical systems is statistically and positively associated with mean effectiveness (MGT) at the .05 level and correlated with learning environment at the .01 level. A correlation analyses of all of the variables in this study are provided in Table 4.16 located in Appendix F.

Table 4.4

Correlation of Independent Variables with Dependent Variables

Independent Variables	**Dependent Variables**					
	MGT	CLS	JS	LE	PTP	TE
1. Supervisory Behaviors	.08	.29**	.67**	.68**	.36**	.16
2. Management Support	-.12	.53**	.69**	.62**	.71**	.34**
3. Cooperative L-M Relations	-.06	.35**	.38**	.39**	.62**	.27*
4. Developmental Focus.	-.23*	.39**	.67**	.63**	.59**	.24*
5. Managing Change	.07	.51**	.52**	.68**	.65**	.34**
6. Teamwork	.16	.41**	.36**	.59**	.41**	.54**
7. Psychological Participation	.09	.44**	.48**	.66**	.35**	.20
8. Process Focus	.08	.43**	.55**	.58**	.61**	.59**
9. Proactive Problem Solving	.08	.49**	.47**	.65**	.47**	.47**
10. Workplace Trust	-.06	.26*	.53**	.52**	.38**	.54**
11. Workplace Bonding	.10	.35**	.43**	.60**	.28*	.36**
12. Workplace Bridging	-.22*	.29**	.62**	.56**	.58**	.33**
13. Conflict Resolution	-.17	.34**	.56**	.57**	.48**	.09
14. People Systems Composite	-.03	.46**	.64**	.75**	.58**	.41**
15. Lean Training	.43**	.08	-.06	.15	-.13	.17
16. Integration	.73**	.11	-.23*	.10	-.20	.03
17. Technical Systems	.82**	.16	-.05	.28*	.04	.17

Listwise N = 66.
Where: MGT = Mean score of supervisor and superintendent rating of department effectiveness; CLS = Commitment to Lean Strategy; JS = Job Satisfaction; LE = Learning Environment; Perceived Team Performance = PTP; and, TE = Team Efficacy.
**Correlation is significant at the .01 level (1-tailed).
*Correlation is significant at the .05 level (1-tailed).

Factor Analysis

This section of chapter 4 will present the factor analysis for the people systems assessment instrument. Next, the results of the factor analysis of the technical assessment instrument will be presented.

Factor Analysis for People Systems

Exploratory factor analysis using varimax rotation was used to assess the factorial structure of the thirteen people systems scales and lean training (see Appendix A). The principal components method was used and the rotation converged in five iterations upon three interpretable factors. Table 4.5 shows the rotated factor matrix. Overall, these factors accounted for 75.20% of the variance in these data.

Factor 1 consists of the following scales: 1) Labor management relations; 2) Managing change; 3) Management support; 4) Process focus; 5) Workplace bridging; 6) Problem solving; and, 7) Team work. These seven scales accounted for 32.81% of the total variance in these data. For the purpose of this study, factor 1 will be labeled as inter group connections.

Factor 2 consists of the following scales: 1) Involvement psychology; 2) Supervisor behavior; 3) Workplace bonding; 4) Conflict resolution; 5) Developmental focus; and, 6) Workplace trust. These six scales accounted for 32.52% of the total variance in these data. Factor 2 will be labeled as intra group connections. Factor 3 consists of eight yes/no lean production training questions that accounts for 9.86% of the variance and will be labeled as lean training.

Correlation analysis was conducted on these three factors and a strong statistical significant relationship between factor 1 and factor 2 ($r = .78$) was found. Even after factor 1 was limited to include just labor management relations through workplace bridging, and factor 2 was amended to include involvement psychology through conflict resolution, a strong statistical significant relationship was still found between these factors ($r = .65$). In neither case was lean training (factor 3) found to be significantly correlated with factor 1 (i.e., $r = .02$ in the first case and $r = -.09$ in the second case) or factor 2 (i.e., $r = .03$ in the first case and $r = .06$ in the second case).

As a result people systems is divided into two factors for this analysis. Factor one is based on all those items identified in factor 1 and 2 above and is identified as people systems composite. The second factor of people systems will be based solely on lean training. The correlation is .02 between lean training and people systems composite.

Table 4.5

Results of Factor Analysis of Lean Production People Systems Scales

	Factor Loadings		
	1	2	3
Labor management relations	.87	.05	-.21
Managing change	.76	.38	.15
Management support	.76	.39	-.09
Process focus	.74	.36	.36
Workplace bridging	.70	.53	-.23
Problem solving	.67	.55	.21
Teamwork	.55	.53	.35
Involvement psychology	.21	.84	.22
Supervisory behavior	.26	.81	-.05
Workplace bonding	.24	.78	.18
Conflict resolution	.38	.75	-.25
Developmental focus	.54	.65	-.18
Workplace trust	.53	.53	.03
Lean training	-.05	.01	.88

N=67

Factor Analysis for Technical Systems

Exploratory factor analysis using varimax rotation was used to assess the factorial structure of the 12 technical system questions (see Appendix B). The principal components methods was used and the rotation converged in three iterations upon two factors. Table 4.6 shows the rotated matrix. Overall, these two factors accounted for 71.76% of the variance in these data.

The 12 questions in the technical assessment instrument are based on six different areas of lean production. Each of the six technical aspects of lean production consisted of two questions. The six areas included the following: 1) Flow manufacturing; 2) Employee involvement; 3) Workplace organization; 4) Quality; 5) Operational availability; and, 6) Material movement. This instrument measures the current status of lean production at the department and shift level in terms of the technical aspects of lean production. As noted previously, question 9 and 13 was excluded from this analysis as a result of low response rate on these items. Process capability was not answered because the item appeared to be confusing to the respondents. In the case of quick-set up, this process is not used extensively in some work situations.

As shown in Table 4.6 items 5, 6, 4, 7, 2 and 15 formed factor 1. This factor may be labeled workplace organization and employee support. Factor 1 accounted for 40.74% of the variance in these data.

Table 4.6 also shows that items 8, 1, 14, and 12 formed factor 2. This factor may be labeled external support and quality. This factor accounted for 31.02% of the variance in these data.

Correlation analysis was conducted on these two factors and strong statistical significant relationship between factor 1 and factor 2 was (r = .67) found. If factor 1 is limited to items 5, 6, 4, and 7, a strong statistical significant association (r = .61) between the amended factor 1 and factor 2 prevails. As a result, a single scale will be used for technical systems in this analysis. The reliability coefficient for the technical systems instrument is .91 (alpha).

Table 4.6

Results of Factor Analysis of Lean Production Technical Systems

	Factor Loadings	
Item	**1**	**2**
5. Natural workgroup	.88	.23
6. Clear, clean, organized & maintained	.88	.08
4. Cross function & skills	.84	.38
7. Visual controls	.79	.25
2. Takt time	.75	.42
15. Internal material delivery	.55	.47
8. Inspection & testing	.02	.91
1. Organized by value stream	.31	.77
14. Container right sizing & operator support	.37	.76
12. Owner operator	.31	.70

N=50 listwise.

Results of Analyses of Hypothesis

This section of Chapter Four will conduct the tests of the hypotheses. The plant located in the Southeast was unable to provide archival data at the department and shift level. As such, the analyses related to archival performance measures will be limited to the plant located in the Midwest. All other analysis will be based on data supplied by both facilities.

The archival performance data originally designed into this research project included cost, productivity, quality, delivery and suggestion data. Representatives from each location assured this researcher that ample data would be available at the department level. However, after a great deal of effort, the plant located in the Southeast was unable to provide any useful data at the department level and the plant located in the Midwest was only able to provide suggestion and uptime data at the appropriate level for this study. Because on the reduced number of the departments included in the analysis related to the archival performance data the opportunity to find significant results is substantially diminished. In addition, since the two plants were chosen to participate in the research based on anticipated variance, by eliminating one of the plants from the archival performance analysis further reduced the opportunity for significant findings.

Three types of hypothesis testing will be conducted. For hypotheses 1 through hypotheses 5 multiple linear regression will be used. Moderation hypothesis testing will be used for hypothesis 6 through hypothesis 8. And, mediation hypothesis testing will be used for analyzing hypotheses 9 through 11. Department size is a control variable for each hypothesis and will be covaried out in step one for each hypothesis.

Hypothesis 1

Hypothesis 1 states that the technical systems of lean production are positively and significantly related to department performance. That is, as department ratings of the technical elements of lean production increase department performance measures improve. Department performance measures in this analysis include the number of employees to make at least one suggestion per department and shift annually calculated as suggestion participation rate (for calendar year 1999) and uptime by department and shift as a percent of uptime over an eight month period (January through August, 1999). Table 4.7 shows the results. Technical systems had no statistical significant impact on suggestion participation or uptime. Hypothesis 1 is not supported.

While the technical systems of lean production was not a significant predictor of department performance, the limited performance data made available by the plant located in the Midwest significantly limited the opportunity to find significant results. Uptime data has little variance across the departments in this study. While uptime performance is an important measure for manufacturers it has limited capability in delineating mass from lean producers. This is a counter intuitive point, yet important. Mass producers are driven by production numbers and as such attempt to maintain high uptime to maximize output. In contrast, lean producers also strive to for output, but use uptime performance as tension to drive improvement efforts. High uptime performance may suggest good performance, but it may also be an indicator of poor improvement in terms of incremental improvement efforts through the elimination of waste. This tension provides a key competitive advantage for lean producers founded on the integration of the technical and people systems of lean production.

In addition, the suggestion data tracked and provided for this study at the department level has limited potential for this analysis. For example, each member of a department could make one suggestion in 1999 and receive the same measure for suggestion rate as another department in which each member of a department provided five suggestions. That is, once a department member made just one suggestion, any future suggestions by that member are irrelevant in calculating the suggestion rate for that department.

Moreover, without the data from the plant located in the Southeast, potential variance among the participating departments in this study is significantly reduced. This limitation is not limited to just the reduced number of departments included in the study (i.e., a smaller N). It is also specific to this study. Each of the locations were identified as following a diffusion strategy in the adoption of lean production as either a more technical focused or a more integrated application of lean production. As such, the possible variance in the study was significantly reduced for assessing hypothesis 1.

Table 4.7

Regression Results of the Test for Technical Systems Effect on Suggestion Participation Rate and Uptime

Independent Variables	Suggestion Participation	Uptime
Step 1: Control		
Team Size (Beta)	-.04	.11
R square	*.00*	*.02*
Step 2: Main Effect		
Technical Systems (Beta)	.20	.31
R square change	*.04*	*.09*

N = 26
*p<.10, **p<.05, and ***p<.01

Hypothesis 2

Hypothesis 2 states that the technical systems of lean production are positively and significantly related to perceived department effectiveness. In other words, the adoption of the technical components of lean production will result in the perception of improved department effectiveness. This hypothesis was tested using linear regression analyses. The results are shown in Table 4.8. Technical systems were regressed with perceived effectiveness. The results, after controlling for department size, indicate a positive and significant relationship between technical systems and perceived effectiveness. That is, as department ratings of the technical elements of lean production increase, perceived department effectiveness improves as rated by supervisors and superintendents (MGT). This relationship was significant at the .01 level. However, after controlling for team size, this same relationship was not significant as assessed by department level employees (PTP). Hypothesis 2 is therefore supported in part, when assessed by management level employees, but not supported when assessed by department level employees.

The partial support for hypothesis 2 suggests that managers and employees at the department level differ significantly in terms of their perceptions related to the adoption of the technical systems of lean production and its impact on performance. These results for managers are consistent with a "Tayloristic" or scientific management perspective on change. That is, managers view the brownfield conversion to lean production as a technological transformation.

Table 4.8

Regression Results of the Test for Technical Systems Effect on Perceived Effectiveness and Work-Related Attitudes

	Dependent Variables					
Independent Variables	**Perceived Effectiveness**		**Work-Related Attitudes**			
	MGT	PTP	CLS	JS	LE	TE
Step 1: Control						
Team Size						
Beta	-.19**	.38**	.23	.43***	.40***	.28*
R square	*.063**	*.10***	*.065*	*.10***	*.19****	*.09***
Step 2: Main effect						
Technical Systems						
Beta	.91***	-.14	.06	-.25*	.10	.04
R square change	*.63****	*.02*	*.00*	*.05**	*.01*	*.00*

N=66
*p<.10, **p<.05, and ***p<.01

Where: MGT = Superintendent and Supervisor rating of perceived effectiveness; PTP = Employee rating of perceived department performance; CLS = Commitment to lean strategy; JS = Job satisfaction; LE = Learning environment; TE = Team efficacy.

Hypothesis 3

Hypothesis 3 asserts that people systems of lean production are positively and significantly related to department performance. In other words, as department ratings of the people systems of lean production increase, department performance measures improve. As stated above, department performance measures include the number of employees to make at least one suggestion per department and shift annually calculated as suggestion participation rate and uptime by department and shift as a percent of uptime over an eight-month period. Also stated above, this hypothesis will be limited to the plant located in the Midwest. Table 4.9 shows the results of the regression analysis. People systems measures include people systems composite (composite) and lean training (training). People systems had no statistical significant impact on suggestion participation or uptime. Hypothesis 3 is not supported.

Table 4.9

Regression Results of the Test for People Systems Effect on Suggestion Participation Rate and Uptime

Independent Variables	Suggestion Participation	Uptime
Step 1: Control		
Team Size (Beta)	.10	.06
R square	*.00*	.02
Step 2: Main Effect		
People Systems		
Composite (Beta)	-.06	.14
Training (Beta)	.30	.03
R square change	*.09*	.02

N = 26
*p<.10, **p<.05, and ***p<.01

Table 4.10

Regression Results of the Test for People Systems Effect on Perceived Effectiveness and Work-Related Attitudes

	Dependent Variables					
Independent Variables	**Perceived Effectiveness**		**Work-Related Attitudes**			
	MGT	PTP	CLS	JS	LE	TE
Step 1: Control						
Team Size						
Beta	.20	.06	.00	.08	.10	.10
R square	*.05**	*.07***	*.11****	*.04*	*.16****	*.07***
Step 2: Main effect						
People Systems						
Composite (Beta)	-.11	.55***	.14***	.69***	.67***	.34***
Training (Beta)	.40***	-.13	.03	-.06	.11	.15
R square change	*.16****	*.27****	*.09***	*.40****	*.39****	*.12***

* p < .10
** p < .05
*** p < .01

Hypothesis 4

Hypothesis 4 states that the people systems of lean production are positively and significantly related to perceived department effectiveness. That is, the adoption of the people system components of lean will result in the perception of improved department effectiveness. The two measures of people systems are used in this analysis include; people systems composite (composite), and lean training (training). Table 4.10 provides the results of this analysis. The two measures of people systems were regressed with perceived effectiveness at the supervisor and superintendent level (MGT) and department employee level (PTP). The results identify no statistical significant relationship between people systems composite (composite) and perceived improved effectiveness at the management (MGT) level (B = -.11). However, there is a statistically significant relationship between lean training (training) and perceived improved effectiveness as rated by supervisor and superintendents (MGT) at the .01 level (B = .40). The R square change attributable to the lean training factor of people systems is .16.

In contrast, when the two measures of people systems are regressed with perceived effectiveness as rated by employees the reverse was found. The people systems composite (composite) is statistically related to perceived performance as rated by department level employees (PTP) at the .01 level (B = .55). However, lean training (training) is not statistically associated with perceived performance at the employee level. The R square change accounted for by people composite systems is .27. Hypothesis 4 was partially supported.

The findings in hypothesis 4 provide further support to differences in perceptions of managers and employees in the transformation to lean production. That is, managers perceive no relationship between people systems of lean production and department performance. However, lean training is associated with perceptions of improvement in department performance. The findings in hypothesis 4 coupled with hypothesis 2 suggests that managers perceive the transformation to lean production as phenomenon driven by technological change combined with changes by their employees achieved through lean training. However, the reverse findings found for employees suggest that employees look for changes in management behaviors (people systems) not technological change or training. Or put differently, employees believe changes have occurred when they observe changes in management behaviors.

Hypothesis 5

Hypothesis 5 states that the people systems of lean production are positively and significantly related to work-related attitudes. Table 4.10 shows the results of this hypothesis. These work-related attitudes include commitment to lean strategy (CLS), job satisfaction (JS), learning environment (LE), and team efficacy (TE). In other words, the adoption of the people system components of lean production will result in improved employee perceptions of work related-attitudes. A positive and statistically significant relationship between people systems and work-related attitudes indicate that, as the rating of people systems increases, work-related attitudes towards commitment to lean strategy, job satisfaction, learning environment, and team efficacy improves. When people systems composite (composite) were regressed with each of the work-related attitudes, the composite measure was found to have a positive and statistically significant association with each of the work-related attitudes at the .01 level. In contrast, lean training (training) had no impact on work-related attitudes. Hypothesis 5 was partially supported.

Hypothesis 5 provides further support to the suggestion above that employees look to changes in management behaviors. These findings suggest that training can provide understanding, but change occurs when behaviors change – not good intentions.

Moderation Hypothesis Testing

This second set of hypothesis testing that follows (hypotheses 6-8) involves moderating hypotheses. Moderation was tested using multiple regression. Two cross-products are formed by multiplying the independent variables. A significant regression for the cross product terms indicate the presence of an interaction. The means are evaluated to see the direction of the interaction. One cross-product is created by multiplying technical systems by people systems composite (i.e., tech. x composite). A second cross-product is created by multiplying technical systems by lean training (i.e., tech. x training). The results are presented in Table 4.11 and Table 4.12.

Hypothesis 6

Hypothesis 6 states that the consonance between the technical systems and people systems in lean production are positively and significantly related to department performance. In other words, the congruence between the technical systems and people systems in lean production is predicted to moderate the effects of these systems resulting in improved performance. Again, department performance measures in this analysis include the number of employees to make at least one suggestion per department and shift annually calculated as suggestion participation rate and uptime by department and shift as a percent of uptime over an eight-month period. Table 4.11 shows the results of the regression analyses. Again, this analysis is limited to the plant located in the Midwest. The cross-product variables (tech. x composite and tech. x training) were regressed with suggestion participation rate and uptime. The control variable as well as the independent variables was not found significant. And, the cross-products or interaction was not statistically significant. Hypothesis 6 was not supported.

Hypothesis 7

Hypothesis 7 asserts that the consonance between the technical systems and people systems in lean production are positively and significantly related to perceived performance. In other words, departments in which the technical systems and people systems that are congruent are more likely to perceive enhanced department effectiveness. Therefore, perceived effectiveness was regressed on the independent variables and the cross-products. Table 4.12 shows the results of the regression analysis. The results indicate a significant relationship between technical systems ($B = 1.58$, $p<.01$), and lean training ($B = 1.04$, $p<.05$) with perceived effectiveness at the supervisor and superintendent level (MGT). Also, a significant and negative association with the interaction between technical systems and lean training (tech. x training) ($B = -1.27$, p.01) with perceived effectiveness as rated by supervisors and superintendents (MGT). No interaction effect was found for perceived performance as assessed by employees (PTP). Hypothesis 7 was not supported.

One viable explanation for the negative relationship between the interaction of technical systems and lean training as assessed by the management level is that management may perceive investment in training as having a negative impact on production goals. That is, if employees are spending time in training during working hours, these employees are not available to perform production activities. However, as indicated in hypothesis 2, once the initial investment is made in training, management (i.e., supervisors and superintendents) value employee increased capabilities in terms of perceived department performance.

Hypothesis 8

Hypothesis 8 states that the consonance between the technical systems and people systems in lean production are positively and significantly related to work-related attitudes. In other words, departments in which the technical systems and people systems are congruent are more likely to have a positive impact on work-related attitudes. Therefore, each of the work-related attitudes was regressed on the independent variables and the cross-products. The results of this analysis are presented in Table 4.12. A significant interaction effect was found for job satisfaction (JS) and technical systems and people systems composite (tech. x composite) ($B = 1.60$, $p<.05$) as well as a significant negative interaction effect for technical systems and lean training (tech. x training) ($B = -1.32$, $p<.05$).

The results in Table 4.12 also show a significant negative interaction effect for learning environment (LE) and technical systems and lean training (tech. x training) ($B = -1.57$, $p<.01$). A positive and significant interaction effect was found for team efficacy (TE) and technical systems and lean training (tech. x training) ($B = 1.76$, $p<.05$).

The significant interaction effect for job satisfaction and technical systems and people system composite supports the proposition that work organizations will perform effectively only to the extent that their people systems are compatible with the technical systems. This finding suggests that people systems consistent with a lean production context provides increased job satisfaction for employees when compared with departments that have not made similar changes in people systems. In contrast, significant negative interaction effect for job satisfaction and technical systems and lean training suggests that training without requisite changes in people systems may frustrate employees resulting in decreased job satisfaction. These findings provide additional support for the proposition that training can provide understanding, but change occurs when behaviors change – not good intentions promoted in lean training.

In addition, the significant interaction effect for team efficacy and lean training also supports the consonance hypothesis. This finding appears to support the basic concept of team efficacy. Team efficacy is a measure of a team's belief that they can positively impact their performance. The interaction of lean training and technical systems indicates that lean training impacts a team's belief in their ability to have a positive impact on team performance.

The significant negative interaction of learning environment and technical systems and lean training is counter to hypothesis 8. While this finding in-part challenges hypothesis 8, a discussion of this finding coupled with the discussion of the results of hypotheses 9 through 11 may help explain this finding, which will be discussed later in this chapter.

The finding in support of significant moderation was limited in this study. A plausible explanation is the limited power given the number of observations decreased to 26 for the archival performance data. As stated earlier the limited performance measures (i.e., suggestion rate and uptime) and the reduced variance caused by only one plant supplying performance data also decreased the opportunity to find significant results. In addition, reduced reliability is inherent in the calculation of an interaction effect. For example, if two variables have a reliability of .80, the reliability of the interaction variable is .64 (i.e., .80 x .80 = .64). Yet, given these limitations a moderation effect was found for job satisfaction and team efficacy.

Table 4.11

Regression Results of the Test for Moderation of Technical and People Systems on Suggestion Participation Rate and Uptime

Independent Variables	Suggestion Participation	Uptime
Step 1: Control		
Team Size (Beta)	.16	.10
R square	*.00*	*.02*
Step 2: Main Effect		
Technical Systems (Beta)	.69	-.71
People Systems:		
Composite (Beta)	.03	-.73
Training (Beta)	.69	-.46
R square change	*.17*	*-.09*
Step 3: Interactions		
Tech. x composite	-.36	1.21
Tech. x training	-.37	.58
R square change	*.00*	*.01*
Overall adjusted R square	*-.02*	*-.18*
Overall model F	.92	.41
Standard error of the estimate	.26	14.57

N = 26
*p<.10, **p<.05, and ***p<.01

Table 4.12

Regression Results of the Test for Moderation of Technical and People Systems on Perceived Effectiveness and Work-Related Attitudes

	Dependent Variables					
Independent Variables	**Perceived Effectiveness**		**Work-Related Attitudes**			
	MGT	PTP	CLS	JS	LE	TE
Step 1: Control						
Team Size						
Beta	-.16	.05	.05	-.04	-.85	.14
R square change	.07*	10**	.10**	.10**	.19***	.09**
Step 2: Main effects						
Technical Systems						
Beta	1.58***	-.58	-.15	-.89	.48	-1.57
People Systems:						
Composite (Beta)	.07	.19	.05	.03	.61*	1.19
Training (Beta)	1.04**	-.04	.30	.93**	1.10***	-1.12
R square change	*.64****	*.25****	*.19***	*.46****	*.45****	*.17***
Step 3: Interactions						
Tech. x composite	0.26	.78	.90	1.60**	.48	1.03
Tech. x Training	-1.27 ***	-.14	-.68	-1.32**	-1.57 ***	1.76**
R square change	*.04***	*.01*	*.02*	*.07***	*.06***	*.19***
Overall adjusted R square	*.73*	*.28*	*.22*	*.58*	*.66*	*.27*
Overall model F	23.60***	4.3***	3.4***	12.76***	18.60***	4.2***
Standard error of the estimate	.82	.46	.37	.34	.25	.76

Mediation Hypothesis Testing

This third set of hypothesis testing that follows (hypotheses 9-11), involves mediation hypotheses. The model hypothesizes that integration mediates the relationship between technical systems and department performance (archival and perceived) as well as work-related attitudes (commitment to lean strategy, job satisfaction, learning environment, and team efficacy). Likewise, the model hypothesizes that integration mediates the relationship between people systems (people systems composite and lean training) and department performance (archival and perceived) as well as work-related attitudes (commitment to lean strategy, job satisfaction, learning environment, and team efficacy). The existence of a mediation effect requires that the mediation variable (in this case integration is the mediating variable) adds to the prediction of the dependent variables over and above the independent variables. This is determined by evaluating the beta weights of the independent variables to observe if the independent variables become non-significant or become lower. That is, the beta weights are compared when the main effect is entered before the mediator (equation 1, Table 4.13), and when the mediator is entered before the main effect (equation 2, Table 4.13).

Hypothesis 9

Hypothesis 9 states that the relationship of the technical systems and people systems with department performance will be partially mediated by integration practices. In other words, the effects of the mediating variable (i.e., integration) will explain variance above and beyond the variance explained by the technical and people systems of lean production. As stated above, department performance measures in this analysis include the number of employees to make at least one suggestion per department and shift annually calculated as suggestion participation rate and uptime by department and shift as a percent of uptime over an eight-month period.

The results in Table 4.13 show that that lean training (training) was positively related to suggestion participation ($B = .43$, $p<.05$). However, the data also shows that integration did not explain a significant increase in variance above technical systems or people systems. That is, integration explained all of the variance explained in suggestion participation. In addition, integration was positively related to uptime performance ($B = .59$, $p<.10$). The results show that integration accounted for all of the variance explained in uptime performance (change in R square in equation 1 = .13, $p<.01$ and change in R square in equation 2 = .18, $p<.05$). Thus, the results do not support the mediated relationship proposed in hypothesis 9.

Table 4.13

Regression Results of the Test of Integration as a Mediator for Technical and People Systems Effect on Suggestion Participation Rate and Uptime

Independent Variables	Suggestion Participation	Uptime
Equation 1		
Step 1: Control		
Team Size (Beta)	.35	.26
R square	*.00*	*.02*
Step 2: Main Effect		
Technical Systems (Beta)	-.16	-.14
People Systems:		
Composite (Beta)	.04	.16
Training (Beta)	.43**	.16
R square change	*.17*	*.09*
Step 3: Mediator		
Integration (Beta)	.63**	.59*
R square change	*.12***	*.13**
Equation 2		
Step 1: Control		
Team Size (Beta)	.35	.26
R square	*.00*	*.02*
Step 2: Mediator		
Integration (Beta)	.63**	.59*
R square change	*.14***	*.18***
Step 3: Main Effect		
Technical Systems (Beta)	-.16	-.14
People Systems:		
Composite (Beta)	-.04	.16
Training (Beta)	.43**	.16
R square change	*.16*	*.04*

N=26.

Hypothesis 10

Hypothesis 10 states that the relationship of the technical systems and people systems with perceived performance will be partially mediated by the integration practices. That is, it was predicted technical and people systems will be positively related to perceived effectiveness. Second, that the positive relationship between these independent variables and perceived performance measures would be partially mediated by the studies integration measures. The results of this test can be found in Table 4.14. The results for supervisor and superintendent rating of perceived effectiveness (MGT) was related technical systems ($B = .93$, $p<.01$). People systems composite (composite) and lean training (training) are not positively related to perceived effectiveness at the supervisor or superintendent level. The test for mediation was not supported.

In the case of perceived department performance (PTP) as rated by employees, both technical systems ($B = .53$, $p.<.10$) and people systems composite ($B = .45$, $p.<.01$) are positively related to employee ratings of effectiveness. However, the test of mediation was not supported. Hypothesis 10 is not supported.

Hypothesis 11

Hypothesis 11 states that the relationship of the technical systems and people systems with work-related attitudes will be partially mediated by the integration practices. That is, it was predicted that technical systems and people systems are positively associated with work-related attitudes. Also, that the positive relationship between these independent variables and work-related attitudes would be partially mediated by integration. The results are presented in Table 4.14. The results show that technical systems are not statistically associated any of the work-related attitudes. Also, lean training (training) is not statistically related to any of the work-related attitudes. Table 4.14 shows that people systems composite is positively related to commitment to lean strategy (CLS) ($B = .45$, $p<.01$), job satisfaction (JS) ($B = .70$, $p<.01$), learning environment (LE) ($B = .77$, $p<.01$), and team efficacy (TE) ($B = .38$, $p<.05$). None of the tests of mediation were supported. That is, people systems composite explained all of the variance in work-related attitudes. Hypothesis 11 is not supported.

While none of the integration hypotheses were supported in this study, a further discussion of hypothesis 8 coupled with the integration hypotheses, and a discussion of the measurement issues related to integration may in part explain these results.

The key measurement constraint in this aspect of this study was that the assessment of integration was folded into the larger technical assessment instrument. The specific items measured by the integration items (i.e., items 3, 10, 11, and 16 in Appendix B), where significantly different from the technical systems in terms of face validity. In fact, these survey items were created by lean experts and a review of the integration items compared with the technical systems assessment items reveals a clear focus on changed behaviors by employees. However, all of these items on the assessment instrument was assessed solely by the superintendent level. A total of 12 superintendents completed all of the technical assessment, which included the integration assessment instrument. As a result, the variance between departments and between the technical systems and integration items may have been significantly reduced. This is supported by the high correlation between the technical and integration items on the survey instrument ($r = .87$). (See Appendix F.) While alternative methods to collect integration data were discussed and recommended by the researcher, the approached used in this study was the only option available.

As found in hypothesis 8, the significant negative interaction of learning environment and technical systems and lean training appears to be counter intuitive, yet, consistent with the concept of integration proposed in this study. The key components of integration as defined in this study include: 1) A suggestion system in which team members use and understand, a suggestion system that documents activities, improvements are tracked, and suggestion data is a key measure for the team, department and plant; 2) Teams use specific lean tools for continues improvement, teams determine the best work methods and adjust these methods to match takt time; 3) Disciplined problem solving is in place and is consistently followed, these problem solving activities have become a change management process achieving a continuous incremental improvement process, and problem solving processes are folded into future product and processes; and, 4) Operational availability concepts are understood and accurate, data collection and analysis are tied directly to operational availability, and this data and analysis drives continuous improvement efforts.

The negative interaction of learning environment and technical systems and lean training would appear consistent with this finding. If department employees are provided the technical systems and trained in lean production without the opportunity to use the lean technical systems and their capabilities through training, the integration activities described above will likely result in a decrease in a learning environment, which is consistent with this finding. The measures for perceived learning environment are based on specific behaviors and actions. For example, people in my department are encouraged to continuously improve. And, successful people at my company continually try new things. The implementation of the technical elements of lean production coupled with lean training without the opportunity to actively participate in improvements (i.e., as contained within the integration variable) will result in lower ratings of the perceived learning environment as assessed by employees, which is consistent will this finding.

In addition, this position is supported further by the findings in hypothesis 9. Integration was the only independent variable to be positively related to department performance (i.e., suggestion rate and uptime). As stated earlier, the measures provided for department performance and the fact that only one of the two sites in this study was able to provide performance data at the department and shift level substantially reduced the opportunity find significant data. Yet, integration still was significantly related department performance.

In short, these findings suggest that integration is dependent upon the technical systems and lean training as a fundamental foundation for integration to occur. People systems create the climate that allows employees at the department level to have a direct impact on department performance.

Table 4.14

Regression Results of the Test of Integration as a Mediator for Technical and People Systems Effect on Perceived Effectiveness and Work-Related Attitudes

Independent Variables	Dependent Variables					
	Perceived Effectiveness		Work-Related Attitudes			
	MGT	PTP	CLS	JS	LE	TE
Equation 1						
Step 1: Control						
Team Size (Beta)	-.12	.03	.02	.06	.00	.11
R square	.07*	.10**	.10**	.10**	.19***	.09**
Step 2: Main effect						
Tech. Sys. (Beta)	.93***	.53*	.24	-.11	.15	-.04
Training (Beta)	.11	-.18	-.20	-.05	-.07	.23
Composite (Beta)	-.12	.45***	.45***	.70***	.77***	.38**
R square change	.65***	.25***	.18***	.46***	.45***	.17**
Step 3: Mediator						
Integration (Beta)	-.09	-.57**	.03	-.08	.07	.00
R square change	.00	.06**	.00	.00	.00	.00
Equation 2						
Step 1: Control						
Team Size (Beta)	-.12	.03	.02	.06	.00	.11
R square	.07*	.10**	.10**	.10**	.19***	.09**
Step 2 : Mediator	-.09					
Integration (Beta)		-.57**	.03	-.08	07	.00
	.47**					
R square change		.08**	.00	.11**	.00	.00
Step 3: Main effect						
Tech. Sys. (Beta)	.93***	.53***	.24	-.11	.15	-.04
Training (Beta)	.11	-.18	-.20	-.05	-.07	.22
Composite (Beta)	-.12	.45***	.45***	.70***	.77***	.38**
R square change	.19***	.23***	.18**	.35***	.45***	.17**

Summary of Hypotheses

Table 4.15 summarizes the significant relationships between technical systems and people systems as well as significant relationships of integration as a mediating variable and the cross-products or interaction variables with perceived performance, archival data, and work-related attitudes. It was assessed whether technical systems and people systems predicted department performance and work-related attitudes. It was also assessed whether the congruence between the technical systems and people systems in lean production moderates the effects of these systems resulting in improved department performance and work-related attitudes. Lastly, this study examined whether technical systems and people systems are mediated by integration in its effect on department performance and work-related attitudes.

The main findings of this research is that there is a positive and significant relationship between technical systems and perceived work unit effectiveness as assessed by supervisors and superintendents. The findings support that people systems lean training is positive and significantly associated with perceived performance as rated by supervisors and superintendents and that people systems composite is positive and significantly related to perceived performance as assessed by employees. There is also a positive and significant relationship between people systems composite and each of the work-related attitudes (commitment to lean strategy, job satisfaction, learning environment, and team efficacy).

A positive and significant interaction effect was found for technical systems and people systems composite with job satisfaction. Also, a positive and significant interaction effect was found for technical systems and people systems lean training with team efficacy. These findings support the proposition that the consonance between the technical systems and people systems in lean production is positively and significantly related to work-related attitudes.

Support was not found for the proposition that integration mediates the relationship between technical systems and people systems. Integration accounted for a significant increase in explained variance in terms of suggestion participation rate and uptime performance at the department level. However, the variance explained by integration was a direct effect on the dependent variables and no integration effect was found.

Table 4.15 will now be presented. It summarizes the findings shown in this chapter.

Table 4.15

Comparison of Hypothesized Versus Actual Research Findings

Variable	Hypothesized	Actual
Hypothesis 1: Technical systems, department performance	+	0
Hypothesis 2: Technical systems, perceived department performance		
Rated by supervisors and superintendents	+	+
Rated by department employees	+	0
Hypothesis 3: People systems, department performance	+	0

Hypothesis 4: People systems, perceived department performance		
Management		
Lean production composite	+	0
Lean training	+	+
Employee		
Lean production composite	+	+
Lean training	+	0
Hypothesis 5: People systems, work-related attitudes		
People Systems Composite		
Commitment to lean strategy	+	+
Job Satisfaction	+	+
Learning environment	+	+
Team efficacy	+	+
Lean Training		
Commitment to lean strategy	+	0
Job Satisfaction	+	0
Learning environment	+	0
Team efficacy	+	0

Hypothesis 6: People systems moderate technical systems, department performance		
Technical systems x People systems composite	+	0
Technical systems x Lean training	+	0
Hypothesis 7: People systems moderate technical systems, perceived performance		
Technical systems x People systems composite		
Management	+	0
Employee	+	0
Technical systems x Lean training		
Management	+	-
Employee	+	0
Hypothesis 8: People systems moderate technical systems, work-related attitudes		
Technical systems x People systems composite		
Commitment to lean strategy	+	0
Job Satisfaction	+	+
Learning environment	+	0
Team efficacy	+	0
Technical systems x Lean training		
Commitment to lean strategy	+	0
Job Satisfaction	+	-
Learning environment	+	-
Team efficacy	+	+

Hypothesis 9: Integration mediates technical and people systems, department performance		
Technical systems x people systems composite	+	0
Technical systems x lean training	+	0
Hypothesis 10: Integration mediates technical and people systems, perceived performance		
Management	+	0
Employee	+	0
Hypothesis 11: Integration mediates technical and people systems, work-related attitudes		
Commitment to lean strategy	+	0
Job Satisfaction	+	0
Learning environment	+	0
Team efficacy	+	0

Where:

- represents a significant inverse relationship;
+ represents a significant positive relationship;
0 represents no significant relationship.

Conclusion

Although many hypotheses were fully or partially supported, several were not. While the most plausible explanation is that the archival performance data variable was inadequate in scope and variance due to archival data made available by the Midwest plant and the inability by the Southeast plant to supply any useful archival data, a more thorough discussion of these results is warranted. The discussion of the findings and their implications will be the focus of chapter five.

CHAPTER FIVE

DISCUSSION

This chapter includes a discussion of the results of the dissertation research. This discussion contains an overall summary of the findings presented in Chapter Four compared to the problem as stated in Chapter One. The implications for research and theory, the implications for practice, and suggestions for future research are also presented.

Summary

Manufacturers around the world continue to expend immense effort to implement lean production. However, despite efforts by many manufacturers to implement lean production, few have successfully imitated the Toyota Production System (TPS) (Spear, 1999). The implications in implementing lean production are dramatic for these manufacturers in both short term and long term consequences. Those firms that fail to adequately implement lean production will face significant performance gaps with those manufacturers that achieve a fully integrated implementation of lean production.

Many of these efforts as described by practitioners and the academic community have focused on the technical aspects of lean production. In fact, many organizations have begun to make the shift from mass production to a technically centered approach of lean production (see Figure 2.1). Yet, a key challenge facing manufacturers is to implement people systems consistent with the technical aspects of lean production and to integrate these systems in ways that encourage problem solving at every level of the organization. While the technical aspects of lean production have been extensively studied, few empirical studies have directly studied the people aspects of lean production.

The purpose of this study was to increase understanding of the people elements that foster and support the technical systems in the diffusion of lean production. This study examined the relationship between these elements of lean production as well as the integration of these elements in the implementation of lean production. Also, this study investigated people systems as a moderator of the relationship between technical systems with department performance and work-related attitudes.

Specifically, this study sought to provide empirical evidence that investing in the people aspects of lean production has a positive impact on performance and work-related attitudes beyond the technical systems of lean production. This study examined the relationship between the technical and people systems of lean production as well as the integration of these elements. This study identified key characteristics of lean production and linked these characteristics with effectiveness data and work-related attitudes at the department level. In this study, a set of hypotheses was presented about the relationships between technical systems, people systems, their interaction, and integration as a mediator of these systems as determinants of department performance and work-related attitudes.

The key findings of this study are as follows:

1. The correlation analysis and the factor analysis of the people systems indicate that key people aspects of lean production at the department level can be identified and measured. Then, I found that these measures of people systems can be analyzed in terms of department performance and work-related attitudes. Moreover, the research indicated that the people systems of lean production can be used to provide a more thorough understanding of lean production as well as differentiate between

departments that have adopted a technology centered approach versus an integrated approach in implemented lean production.

2. The technical and people systems of lean production were not a significant predictor of department performance. As stated in Chapter Four, this may be a reflection of the reduced opportunity for variance in the archival data provided by the plant located in the Midwest and the inability of the plant in the Southeast to provide useful data at the department level.
3. Consistent with the hypothesis 2, technical systems of lean production was a significant predictor of perceived department performance as assessed by management. However, technical systems were not a significant predictor of department performance as evaluated by department level employees. This suggests that management and employees at the department level use different factors in assessing perceived performance. This difference in perceptions may also reflect the challenge of brownfield transformation to lean production. Specifically, the unfreezing or unlearning of old routines may occur differently for managers and workers.
4. The people systems composite measure was a significant predictor of perceived performance as assessed by department level employees (hypothesis 4). People systems lean training was not a significant predictor. The reverse was found for management assessment of performance. That is, people systems lean training was a significant predictor and people systems composite was not significant as rated by management. This suggests that department employees associated people systems (i.e., supervisory behavior, management support, etc.) as a composite with improved

perceived department performance. In contrast, management associated lean training efforts with improved department performance. These findings reinforce difference in perceptions by management level and department level employees in the brownfield conversion to lean production.

5. Consistent with hypothesis 4, the people systems composite measure was a significant predictor of work-related attitudes at the department level. This suggests that the investment in people systems have a significant and positive impact on each of the work-related attitudes, which include commitment to lean strategy, job satisfaction, learning environment, and team efficacy, at the department level.
6. Consistent with the "consonance hypothesis," people systems was a moderator of technical systems and work-related attitudes (i.e., job satisfaction and team efficacy). In other words, these findings provide support for the proposition that organizations will perform effectively when their structures (i.e., people systems) are compatible with the requirements and dictates of the technical system.
7. While integration as a mediator of technical systems and people systems was not supported in this study, the operationalization of integration at the shop floor level provides support for two previous studies of integration in a lean production context (Dean, 1991; MacDuffie, 1992). This study provides support for Dean and Snell (1991) by defining integration activities at a fourth level. In addition, this study extends the MacDuffie and Krafcik (1992) findings by providing theoretical support for their argument that problem solving at the shop floor level is where integration occurs. Also, while the integration variable did not demonstrate a mediation effect, it was the sole independent variable to predict department performance. This finding

reinforces the importance of the integration variable as a predictor of department performance.

Implications for Research and Theory

Chapter two described many reasons why people systems and the integration of people and technical systems are important for organizations adopting lean production, and offered two theoretical perspectives as a foundation for this study. The results of this study suggest that people systems predict work-related attitudes and also influence perceptions of department performance by employees. Specifically, the people systems variable was significantly related to commitment to lean strategy, job satisfaction, learning environment, and team efficacy. In support of the STS perspective, these findings support the proposition that work organizations are composed of two interdependent systems. That both the technical (i.e., technical systems) and social factors (i.e., people systems) must be optimized to obtain high organizational performance.

Technical systems were strongly related to management perception of department performance. The people systems composite was found significantly related to employee perceptions of department performance, but not people systems lean training. In contrast, the reverse relationship was shown for management perception of department performance. These findings suggest strong differences in perceptions between managers and employees in the transformation to lean production. These findings suggest that manager's view the transformation to lean production as largely a technological phenomenon supported by changes in employees reinforced through lean training. In contrast, department employees associate the transformation to lean production as a people systems shift demonstrated by changes in behaviors of managers as well as others. In short, the findings that people systems influence perceptions of performance and work-related attitudes are consistent with the sociotechnical systems (STS) and high performance work practices (HPWP) literatures.

People systems composite was found to moderate the relationship between technical systems and work-related attitudes (i.e., job satisfaction). And, people systems lean training moderated the relationship between technical systems and work-related attitudes (i.e., team efficacy). As such these key findings provide empirical support for the "consonance hypothesis," a key aspect of the STS theory from early in its formation. That is, these findings provide support for the proposition that organizations will perform effectively when their structures are compatible with the requirements and dictates of the technical system. Consistent with Rice (1953), Trist (1951), and Walton (1972) and in contrast with Mohr (1971), people systems moderated the relationship between the technical systems and job satisfaction and team efficacy. While Mohr did not find support for the "consonance hypothesis," the author included only supervisory style as a single measure of social structure. In contrast, this study provided several measures of people systems. Mohr's limited measures of social structure might explain his results.

This study also provides theoretical support for the Dean and Snell (1991) study in which the authors argued that a core concept in integrated manufacturing (i.e., lean production) is the elimination of barriers between different facets of a manufacturing operation. This study provides support for this paradigm that "integration mechanisms" suggested by Snell and Dean converge at the shop floor. The authors provided three integration mechanisms, which included integrating functional departments, integrating the stages of production, and by integrating manufacturing goals across the organization. This study provided evidence for a fourth "integration mechanism," which is the integration of the technical systems and people systems at the level of the shop floor.

In addition, this study extends the MacDuffie and Krafcik (1992) findings by providing theoretical support for their argument by suggesting that the interaction of people systems and technical systems at the shop floor level is where integration occurs. MacDuffie and Krafcik describe integration as "incremental problem solving" at the shop floor level and provide data at the firm level. This study extends MacDuffie and Krafcik by identifying key activities that are related to the lean production system that are driven by "incremental problem solving" by department level employees. That is, this study provides support for integration at the level of the department where incremental problem solving occurs in manufacturing facilities and as such closes the gap between the rationale provide by the authors and the level of their analysis.

MacDuffie and Krafcik argued that that the "organizational logic" of lean production is premised on reduced buffers, which provide a direct effect (e.g., reducing the carrying cost of inventories) and a more significant indirect effect of providing valuable information for focused problem solving. That is, the system creates a creative tension between the need to run at reduced inventories and the need for people to solve problems. The authors continue their argument by suggesting that only when human resources put in place the necessary skills and commitment in the work force can incremental improvements be fully harnessed. This study provides the logic and some empirical evidence that the integration of the technical and people systems occurs where value is added to the product through integration activities at the department level.

In additional this study provides specific integration activities as the shop floor level. The key components of integration identified is in this study include: 1) A suggestion system in which team members use and understand, a suggestion system that documents activities, improvements are tracked, and suggestion data is a key measure for the team, department and plant; 2) Teams use specific lean tools for continues improvement, teams determine the best work methods and adjust these methods to match takt time; 3) Disciplined problem solving is in place and is consistently followed, these problem solving activities have become a change management process achieving a continuous incremental improvement process, and problem solving processes are folded into future product and processes; and, 4) Operational availability concepts are understood and accurate, data collection and analysis are tied directly to operational availability, and this data and analysis drives continuous improvement efforts.

While this study did not find a mediating effect of integration as proposed, a direct effect was discovered in the empirical findings. In fact, integration was the only variable found to directly impact the performance data at the department level. This finding argues for further study of integration as proposed in this research.

Implications for Practice

This dissertation provided support for the idea that people systems and technical systems must be integrated to fully capture the full potential of lean production. There are three key implications for practitioners that can be drawn from these findings.

The model for this research entitled A Framework for a Comparative Analysis of Alternative Approaches to the Diffusion of Lean Production in Brownfield Sites (see Figure 2.1) provides a conceptual framework to more fully understand factors influencing the successful diffusion of lean production. For many practitioners the transition to lean production is solely a technical systems transformation. The interviews associated with this research suggest that many practitioners do not consider people systems in the diffusion of lean production. However, those practitioners who have worked in a full lean production system – that is a fully integrated model – accept the technical aspects of lean production as a necessary fundamental ingredient, but focus most of their attention on the people aspects of lean production. As such, this model will assist practitioners by augmenting their current understanding of lean production.

This dissertation provided support for the proposition that people systems must be addressed in the implementation of lean production. Work-related attitudes are shaped by the people systems of lean production. People systems also shape employee perceptions of department performance. This study provides an assessment instrument for practitioners to assess the current state of their organizations and measure progress over time as these organizations convert to lean production as well as assess whether these organizations are maintaining people systems consistent with lean production.

This study also provides support for the proposition that integration activities at the shop floor positively influence department performance. In other words, implementing the technical systems and people systems is not sufficient in the diffusion of lean production. Practitioners need to consider integration activities at the department level that will encourage and support practices that fully capture the full potential of the technical and people systems of lean production. This study provides some ideas on these integration activities for manufacturers.

Suggestions for Future Research

An important assumption in the study of the brownfield conversion of mass production plants into lean production facilities is that change occurs person-by-person, department-by-department, and plant-by-plant. A key suggestion for future research is to conduct construct validation of the people systems assessment instrument. This study suggests that people systems at the individual and department can be measured. A key task for future research is to solidify the key construct that should be considered in measuring people systems in a lean production context.

A second and related item for future research is to compare and contrast mass and lean production facilities using these constructs of people systems. That is, many of the current industrial and organizational constructs were developed in a mass production paradigm. A question for future researchers is whether the current constructs retain their validity in a lean production context.

Another suggestion for future research is to expand the research design across industrial sectors. While this research was conducted in the automotive supplier industry, it included only two facilities within one large corporation. This study could be revised and expanded to include a much larger number and different types of automotive suppliers. Also, this study could be expanded to include other industrial sectors, such as, the steel industry, electronic, and apparel industry. Clearly the technical assessment instrument would need to be adjusted to fit the industrial sector, yet these industries as well as others, are under pressure to become lean producers. For example, the apparel industry from a technical process perspective is driven more by U-shaped cells than the andon systems used in automotive assembly operations. However, each of these industries could be studied in terms of the integration of the people and technical systems of lean production.

Further research will need to address the performance data weaknesses in this study. Two immediate steps could be taken to address this weakness. First, the researcher could develop specific measures related to cost, quality, delivery, suggestions, and productivity independent of any organization's current practices. Second, these data could be tracked over time to address the inherent limitation of a cross-sectional study. However, any such changes must be approved by the participating organizations.

This study provided an important foundation block in terms of understanding human resources and psychological aspects of shifting from mass to lean production environment. It showed that the identification and measurement of the people aspects of lean production is possible. That these measures of people systems are useful in providing increased understanding in terms of the transformation to lean production. This study provided additional support for the proposition that the technical and social systems of lean production needs to be in harmony (i.e., the "consonance hypothesis) to optimize organizational performance. This research identified specific "incremental problem solving" activities at the department level that integrate the technical and people systems of lean production and that these activities directly impact department performance.

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APPENDICES

APPENDIX A

PERCEPTIONS REGARDING THE IMPLEMENTATION OF LEAN PRODUCTION QUESTIONNAIRE

PERCEPTIONS REGARDING THE IMPLEMENTATION OF THE LEAN PRODUCTION

QUESTIONNAIRE

INTRODUCTION

The purpose of this questionnaire is to collect input from employees regarding the effects of a number of changes in the automotive industry. These changes have come about through numerous efforts by management and union to improve the competitive position of your plant and company. Through this questionnaire, we hope to learn more about your opinions regarding these changes. **Please answer all of the questions.**

Participation in this survey is <u>entirely voluntary</u>. You may discontinue participation in the survey at any time. You indicate your voluntary agreement to participate by completing and returning this questionnaire. All responses to the questionnaires will be kept strictly confidential. Further, you should not identify yourself on the questionnaire. <u>No one in the Plant will see the completed surveys</u>. Only group statistics and aggregate results will be disclosed as feedback to your plant and all interested employees. The questionnaires will be processed by the researcher alone. <u>Moreover, the questionnaires will be destroyed once the analysis is complete</u>.

The survey data is being collected and analyzed at the School of Labor and Industrial Relations, Michigan State University. Michigan State University will not permit any responses to be traced back to any individuals or allow individuals to be identified in any other way.

Please take the time to complete the survey. **It should take approximately 20-25 minutes to read and complete the survey.**

If you have any questions, please call the researcher Bill Mothersell at (517) 432-0188.

Thank you for your participation.

Organizational Survey

Department Number: ____________ Work Group/Cell: ______________

Please answer each of the following items by circling the appropriate response.

Please answer the extent to which you agree or disagree with each of the statements listed below using the following scale:

1	**Strongly Disagree**	**SD**
2	**Disagree**	**D**
3	**Neutral**	**N**
4	**Agree**	**A**
5	**Strongly Agree**	**SA**

If an item does not apply to your job please leave it blank.

Supervisory Behaviors:	*SD*	*D*	*N*	*A*	*SA*
1. My advisor/supervisor encourages better relations with other natural work groups/departments.	1	2	3	4	5
2. My advisor/supervisor supports the implementation of the Lean Production.	1	2	3	4	5
3. My advisor/supervisor is willing to adapt his/her supervisory style in response to changes resulting from the move to the Lean Production.	1	2	3	4	5
4. My advisor/supervisor communicates his/her expectations clearly and effectively.	1	2	3	4	5
5. My advisor/supervisor provides timely and beneficial performance feedback.	1	2	3	4	5
6. My advisor/supervisor encourages continuous improvement and innovation.	1	2	3	4	5
7. My advisor/supervisor encourages ideas and suggestions.	1	2	3	4	5
8. My advisor/supervisor encourages teamwork.	1	2	3	4	5
9. My advisor/supervisor goes directly to the work area to observe and discuss problems.	1	2	3	4	5
10. My advisor/supervisor encourages subordinates to participate in important decisions.	1	2	3	4	5
11. My advisor/supervisor encourages people to speak up when they disagree with a decision.	1	2	3	4	5
12. My advisor/supervisor encourages people to try different approaches to solve problems.	1	2	3	4	5
13. My advisor/supervisor believes that people can learn from their mistakes.	1	2	3	4	5
14. My advisor/supervisor views problems and work challenges as opportunities to develop peoples' skills.	1	2	3	4	5

Management Support:	SD	D	N	A	SA
15. Management displays a commitment to Lean Production.	1	2	3	4	5
16. Management establishes policies and procedures that are consistent with Lean Production.	1	2	3	4	5
17. Management is responsive to my suggestions and concerns regarding the implementation of Lean Production.	1	2	3	4	5
18. Management "walks-the-talk" when implementing Lean Production.	1	2	3	4	5
19. Management demonstrates relentless effort to continuously improve.	1	2	3	4	5
20. Management allows decisions to be made at the lowest appropriate level.	1	2	3	4	5
21. Management listens to ideas employees have for making improvements.	1	2	3	4	5
22. I get the information I need from management.	1	2	3	4	5
Cooperative Union Management Relations:	**SD**	**D**	**N**	**A**	**SA**
23. Union objectives and goals are consistent with the objectives and goals of Lean Production in my natural work group/department.	1	2	3	4	5
24. The collective bargaining agreement is structured to facilitate the transition to the Lean Production in my natural work group/department.	1	2	3	4	5
25. Union representatives have had input in the design, monitoring, and evaluation of Production in my natural work group/department.	1	2	3	4	5
26. Union representatives should have input in the design, monitoring, and evaluation of Lean Production in my natural work group/department.	1	2	3	4	5
27. Adversarial relations between union and management prevent my natural work group/department from solving problems.	1	2	3	4	5
28. In my natural work group/department there is little status differential between union and management.	1	2	3	4	5
29. In my natural work group/department union and management representatives work together cooperatively to solve problems.	1	2	3	4	5
Commitment to the Lean Production Strategy:	**SD**	**D**	**N**	**A**	**SA**
30. I am committed to the ideas of the Lean Production.	1	2	3	4	5
31. I think we should increase the emphasis placed on the Lean Production.	1	2	3	4	5

Commitment to the Lean Production Strategy (continued):	SD	D	N	A	SA
32. There is no way that my department can make Lean Production effective.	1	2	3	4	5
33. I understand the key elements of Lean Production.	1	2	3	4	5
34. Lean Production is just a move by management to cut costs.	1	2	3	4	5
Job Satisfaction:	**SD**	**D**	**N**	**A**	**SA**
35. Generally speaking, I am very satisfied with this job.	1	2	3	4	5
36. I am generally satisfied with the kind of work I do in this job.	1	2	3	4	5
37. In general the implementation of Lean Production in my natural work group/department has resulted in increased job satisfaction.	1	2	3	4	5
38. I am satisfied with the physical working conditions in my natural work group/department.	1	2	3	4	5
39. I am satisfied with the recognition my natural work group/department receives for good work.	1	2	3	4	5
Perceived Learning Environment:	**SD**	**D**	**N**	**A**	**SA**
40. People in my natural work group/department are encouraged to continuously improve.	1	2	3	4	5
41. People in my natural work group/department are provided with the opportunity to learn new things.	1	2	3	4	5
42. People in my natural work group/department are encouraged to assume difficult assignments.	1	2	3	4	5
43. In my natural work group/department it is acceptable to question others about why things are done a certain way.	1	2	3	4	5
44. The successful people at my company continually try new things.	1	2	3	4	5
45. In my natural work group/department it is better to ignore problems than to suggest improvements.	1	2	3	4	5
46. In my natural work group/department maintaining the status quo is more important than learning new things.	1	2	3	4	5
47. New ideas are highly valued in my natural work group/department.	1	2	3	4	5
48. In my natural work group/department employees are responsible for demonstrating on the job what they have learned in training.	1	2	3	4	5
49. In my natural work group/department I have some input into the type of training I attend.	1	2	3	4	5
Developmental Focus:	**SD**	**D**	**N**	**A**	**SA**
50. I receive the training I need to perform my job well.	1	2	3	4	5
51. I receive training in teamwork skills.	1	2	3	4	5

Developmental Focus (continued):	**SD D N A SA**
52. My advisor/supervisor is good at coaching me through on-the-job problems.	1 2 3 4 5
53. I am learning how to solve problems better.	1 2 3 4 5
54. I enjoy work changes that require me to learn new things.	1 2 3 4 5
Perceived Team Performance:	**SD D N A SA**
55. The implementation of the Lean Production in my natural work group/department will better enable us to serve our customers.	1 2 3 4 5
56. The implementation of Lean Production in my natural work group/department will allow us to make continuous improvements.	1 2 3 4 5
57. The implementation of Lean Production in my natural work group/department will pit employees against each other.	1 2 3 4 5
58. The implementation of Lean Production in my natural work group/department will assist us in improving quality.	1 2 3 4 5
59. The implementation of Lean Production in my natural work group/department will help us reduce costs.	1 2 3 4 5
60. The implementation of Lean Production in my natural work group/department will assist us in the elimination of waste.	1 2 3 4 5
61. The implementation of Lean Production in my natural work group/department will help us in our overall performance.	1 2 3 4 5
62. The implementation of Lean Production in my natural work group/department will allow us to better solve problems.	1 2 3 4 5
63. The drive to become a lean producer is a passing fad.	1 2 3 4 5
64. The implementation of Lean Production is the right thing to do for our long term success.	1 2 3 4 5
Managing Change:	**SD D N A SA**
65. My advisor/supervisor seeks input from employees regarding how to better Lean Production activities.	1 2 3 4 5
66. My natural work group/department takes steps to remove barriers that prohibit the effective implementation of Lean Production activities.	1 2 3 4 5
67. My natural work group/department takes steps to modify procedures to improve the effective implementation of Lean Production activities.	1 2 3 4 5
68. Our management and union have worked together to explain how the change to Lean Production will benefit the individual worker	1 2 3 4 5
69. Our management and union have worked together to explain how the change to Lean Production will improve our competitive position.	1 2 3 4 5

Please circle the appropriate response for each of the statements listed below using the following scale:

1	**To very little extent =**	**VL**
2	**To a little extent =**	**L**
3	**To some extent =**	**S**
4	**To a great extent =**	**G**
5	**To a very great extent =**	**VG**

If an item does not apply to your job please leave it blank.

Teamwork:	**VL**	**L**	**S**	**G**	**VG**
70. To what extent does your natural work group/department plan together and coordinate its efforts?	1	2	3	4	5
71. To what extent does your natural work group/department make good decisions and solve problems well?	1	2	3	4	5
72. To what extent do persons in your natural work group/department know what their jobs are and know how to do them well?	1	2	3	4	5
73. To what extent is information about important events and situations shared within your natural work group/department?	1	2	3	4	5
74. To what extent is your natural work group/department committed to its objectives?	1	2	3	4	5
75. To what extent is your natural work group/department able to respond to unusual natural work group/department demands placed upon it?	1	2	3	4	5
76. To what extent do you have confidence and trust in the persons in your natural work group/department?	1	2	3	4	5
Involvement/Psychological Participation:	**VL**	**L**	**S**	**G**	**VG**
77. To what extent can you influence what goes on in your natural work group/department?	1	2	3	4	5
78. To what extent can you influence the decisions of your advisor/supervisor regarding things about which you are concerned?	1	2	3	4	5
79. To what extent does your advisor/supervisor ask your opinion when a problem comes up that involves your work?	1	2	3	4	5
80. To what extent can you make suggestions for improving your job or changing the setup in some way?	1	2	3	4	5

Process Focus:	VL	L	S	G	VG
81. To what extent do you understand how your job relates to other jobs in your natural work group/department?	1	2	3	4	5
82. To what extent do you understand how your natural work group/department contributes to the goals of the plant?	1	2	3	4	5
83. To what extent does your natural work group/department continuously strive to make improvements in its key work processes?	1	2	3	4	5
84. To what extent does your natural work group/department monitor key processes to maintain high performance standards?	1	2	3	4	5
85. To what extent does your natural work group/department view its work processes as critical in serving your customer needs?	1	2	3	4	5
86. To what extent do you understand how your natural work group/department relates to your <u>suppliers</u> (e.g., parts/materials suppliers)?	1	2	3	4	5
87. To what extent do you understand how your natural work group/department relates to your <u>customers</u>?	1	2	3	4	5
88. To what extent does your advisor/supervisor stress the importance of maintaining and improving work processes?	1	2	3	4	5
Proactive Problem Solving:	VL	L	S	G	VG
89. To what extent do persons in your natural work group/department take preventive action by focusing on the root causes of problems?	1	2	3	4	5
90. To what extent do persons in your natural work group/department focus on finding long-term solutions to problems?	1	2	3	4	5
91. To what extent do persons in your natural work group/department monitor and evaluate the effectiveness of problem solving strategy implementation?	1	2	3	4	5
92. To what extent do persons in your natural work group/department take calculated risks when engaged in problem solving?	1	2	3	4	5
93. To what extent have persons in your natural work group/department been provided with training in problem solving approaches?	1	2	3	4	5

Proactive Problem Solving (continued):	VL	L	S	G	VG
94. To what extent does you natural work group/department consistently use a particular model of problem solving (e.g., 5-Whys)?	1	2	3	4	5
95. To what extent do persons in your natural work group/department not engage in innovation for fear of getting in trouble should the innovation fail?	1	2	3	4	5
Workplace Trust:	**VL**	**L**	**S**	**G**	**VG**
96. To what extent do you trust that your coworkers would try to help you out if you got into difficulties at work?	1	2	3	4	5
97. To what extent can most of your coworkers be relied upon to do as they say they will do?	1	2	3	4	5
98. To what extent is management at your plant sincere in its attempt to meet the workers' point of view?	1	2	3	4	5
99. To what extent do you feel confident that the company will always try to treat you fairly?	1	2	3	4	5
100. To what extent do you feel management would be quite prepared to gain advantage by deceiving the workers?	1	2	3	4	5
101. To what extent can your management be trusted to make sensible decisions regarding the future of the workers?	1	2	3	4	5
102. To what extent are you confident that your union will always try to treat you fairly?	1	2	3	4	5
103. To what extent can your union be trusted to make sensible decisions regarding the future of the workers?	1	2	3	4	5
Workplace Bonding:	**VL**	**L**	**S**	**G**	**VG**
104. To what extent do you feel you are part of your natural work group/department?	1	2	3	4	5
105. To what extent are persons in your natural work group/department willing to pay attention to what you are saying?	1	2	3	4	5
106. To what extent do persons in your natural work group/department help you find ways to perform a job better?	1	2	3	4	5
107. To what extent are you satisfied that in your natural work group/department everyone's opinion gets listened to?	1	2	3	4	5
108. To what extent do you interact with other members of your natural work group/department in social and recreational activities after work?	1	2	3	4	5
109. When you talk with your advisor/supervisor, to what extent does he/she pay attention to your ideas?	1	2	3	4	5

Workplace Bridging:	VL	L	S	G	VG
110. To what extent does your natural work group/department plan together and coordinate its efforts with other natural work group/departments to get the job done?	1	2	3	4	5
111. To what extent are you and your natural work group/department confident that you will be provided all the necessary resources and help to get the job done in a timely fashion?	1	2	3	4	5
112. To what extent is information about important events and situations in your natural work group/department shared with other natural work groups/departments and vice versa?	1	2	3	4	5
113. To what extent do your internal suppliers provide the help your natural work group/department needs?	1	2	3	4	5
114. To what extent are you satisfied with your interactions with your management at work?	1	2	3	4	5
115. To what extent are you satisfied with the interactions with your union at work?	1	2	3	4	5
116. To what extent are you satisfied with the way the union and management interacts to resolve your natural work group's/department's problems in the workplace?	1	2	3	4	5
117. To what extent is your company involved in volunteer efforts within your community?	1	2	3	4	5
118. How satisfied are you with your company's efforts to help save and preserve the environment in your community?	1	2	3	4	5
119. How satisfied are you with your union's efforts in helping your community?	1	2	3	4	5
120. How satisfied are you with your plant's overall relationship with your community?	1	2	3	4	5

When conflict occurs between you and your advisor/supervisor, to what extent does your advisor/supervisor use each of the following behaviors to resolve conflict? Remember you are rating how your advisor/supervisor behaves when resolving conflict, not how you behave or what you think is desirable.

Describes behavior which **never occurs =**	1
Describes untypical behavior which **seldom occurs =**	2
Describes behavior which **sometimes occurs =**	3
Describes behavior which **occurs frequently =**	4
Describes very typical behavior which **usually occurs =**	5

Conflict Resolution Climate (Forcing/Fostering): My advisor/supervisor…	
121. Brings the problem clearly into the open and carries it out to resolution.	1 2 3 4 5
122. Forces acceptance of his/her point of view.	1 2 3 4 5
123. Emphasizes common interests.	1 2 3 4 5
124. Stresses that our differences are less important than our common goals.	1 2 3 4 5
125. Demands to get his/her way.	1 2 3 4 5
126. Will not take no for an answer.	1 2 3 4 5
127. Imposes his/her solution.	1 2 3 4 5
128. Acts as though our common goals are of prime importance.	1 2 3 4 5
129. Takes both sides of the issue into account.	1 2 3 4 5

Please answer the extent to which you are <u>not at all confident</u> to <u>completely confident</u> using the following scale:

Not at all confident						Completely Confident
1	2	3	4	5	6	7

Team Efficacy: How confident are you that <u>your natural work group/department</u> …	
130. Can solve performance problems?	1 2 3 4 5 6 7
131. Can come up with better ways to do its job?	1 2 3 4 5 6 7
132. Can assess what it does right and wrong?	1 2 3 4 5 6 7
133. Will work hard to meet its responsibilities?	1 2 3 4 5 6 7
134. Can organize itself to maximize its resources?	1 2 3 4 5 6 7
135. Can pull itself out of a slump?	1 2 3 4 5 6 7
136. Can do its job without wasting time?	1 2 3 4 5 6 7
137. Will jump in to solve problems?	1 2 3 4 5 6 7
138. Will go above and beyond its responsibilities?	1 2 3 4 5 6 7
139. Is committed to high levels of production?	1 2 3 4 5 6 7
140. Is committed to the implementation of Lean Production?	1 2 3 4 5 6 7

Demographic Information

Please circle the appropriate response to each of the following items.

Shift:

- Day's/First Shift/A Shift 1
- Afternoon's/Second Shift/B Shift 2
- Midnight's/Third Shift/C Shift 3

Gender:

- Male 1
- Female 2

Years of Service at Plant 6:

- 0 – 2 years 1
- 3 -5 years 2
- 6 - 10 years 3
- 11 - 20 years 4
- 21 – 30 years 5
- More than 30 years 6

Your age:

- 18 years – 25years 1
- 26 years – 30 years 2
- 31 years – 35 years 3
- 36 years – 40 years 4
- 41 years – 45 years 5
- 46 years – 50 years 6
- 51 years – 55 years 7
- Over 55 years 8

Race:

- African American 1
- Asian 2
- Caucasian 3
- Hispanic 4
- Native American 5
- Other 6

Employment Status:

- Hourly Employee 1
- Salaried Employee 2

Do you supervise people?

- Yes 1
- No 2

Work Area/Function:

- Assembly.. 1
- Components (feeder groups) 2
- Quality Assurance... 3
- Support (Skilled Trades, Janitor, Tool Crib, etc.).............. 4
- Production Control & Logistics (PC&L)/Materials Management 5
- Engineering.. 6
- Appointed or Elected Union Official 7
- All Others 8

Have you received any training in the Lean Production?

Yes 1
No 2

If you have received training, what was the training you received? Circle as many as apply.

5S 1

Seven Forms of Waste 2

Introduction to Lean Production 3

People Focused Practices (PFP) 4

Factory Simulation (One Piece Flow,
Level Scheduling & Pull System) 5

Team Building 6

Problem Solving 7

Other Related Training (please identify):
1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Additional Comments:

____
____
____

Thank You For Your Participation

APPENDIX B

IMPLEMENTATION OF LEAN PRODUCTION ASSESSMENT INSTRUMENT

IMPLEMENTATION OF LEAN PRODUCTION

These questions relate to efforts to implement the key elements of lean production at the department level. This assessment instrument is an abbreviated Lean Production Gap Assessment document and has had been modified to focus on lean implementation activities at the department level. Please identify the department number for which the following information is being collected.

Department Number ___________

To answer the following questions, please identify the level at which each department has progressed in implementing lean production. Please answer for just the criteria measure. If a particular question is not applicable for a specific department, please mark as N/A. **Please answer all of the questions.**

This assessment instrument is being collected and analyzed at the School of Labor and Industrial Relations, Michigan State University. This assessment instrument is part of research project focusing on the diffusion of lean production within manufacturing organizations. **Participation in this assessment instrument is entirely voluntary. You may discontinue participation at any time. You indicate your voluntary agreement to participate by completing and returning this instrument.**

Please take the time to complete the assessment instrument. It should take approximately 10-15 minutes to read and complete the assessment instrument for each department.

If you have any questions, please call the researcher Bill Mothersell at (517) 432-0188.

Thank you for your participation.

Flow Manufacturing

Assessment Criteria		Level				Rating
		1	2	3	4	
1. Manufacturing is organized by value stream	Criteria	Product is processed through independent process focused areas (generally a batch process).	Product is processed through independent process focused areas, however, initial planning and execution of product focused areas is underway.	At least 50% of the ***department*** processes are organized by value streams. Plans are being actively developed and executed to fully organize the ***department*** processes by value stream.	Manufacturing ***department*** is organized by value streams that flow from raw material to finished goods.	
	Observables				Feeder processes are co-located with associated assembly for ***department*** value streams.	

Assessment Criteria		Level				Rating
		1	2	3	4	
2. Takt Time	Criteria	Basis understanding of Takt Time exists, however, it is not references as pacing mechanism for ***department*** operations.	Initial efforts are underway to pace ***department*** operations to Takt Time.	Takt Time is referenced by pace most of the ***department's*** production operations.	Takt Time is utilized to pace the ***departments*** production.	
	Observables		Employees understand the value of takt time and its application to their area.	Most part numbers are produced every day to match the pattern of customer demand.	Every part number is produced every day to match the pattern of customer demand.	

Employee Environment and Involvement

Assessment Criteria		Level				Rating
		1	2	3	4	
3. People Focused Practices (PFP)	Criteria	PFP/wall charts do not exist. The work method has not been standardized, there is no correlation of product output to customer demand.	PFP/wall charts are posted for some jobs. The supervisor assigns employees to jobs attempting to balance workloads. There is little understanding of Takt, value-added, non-value-added, and wait time.	PFP/wall charts are posted for all jobs. The NWG determines the best work method. Work load is set by the supervisor with input from the NWG. Takt time is used to determine the resources required.	The NWG uses PFP/wall chart as a tool for continuous improvement. The NWG determines the best work method. NWG adjust work assignments to match Takt. Audit confirms this method is followed across all shifts.	
	Observables		The Industrial Engineer determines the best work method. There is no audit process in place to determine if the best method is being followed.	Audits reveal that this method is not followed across all shifts.		

Employee Environment and Involvement (continued)

Assessment Criteria		Level				Rating
		1	2	3	4	
***4. Cross-functions/* Multi-skills/ Certification**	Criteria	Attainment of cross-functional skills are not encouraged. Job rotation is not structured.	***Department managers*** encourage job-rotation by training the operators on-the-job, with no documentation posted. It is not a ***formalized policy.***	One of the objectives of the NWGs is to develop cross-functions and multi-skills. A training program has been developed to achieve this objective. Certification/versatility charts are posted.	All NWG members are trained to operate all equipment in their assigned area. Certification is documented. The team members follow the documented Roles and Responsibilities. The NWG rotates regularly.	
	Observables					

Employee Environment and Involvement (continued)

Assessment Criteria		Level				Rating
		1	2	3	4	
5. Natural Work Group (NWG) Structure & Support	Criteria	The ***department*** recognizes there is a need for NWGs but there are no structured NWGs in place.	Informal NWGs are formed. Roles and responsibilities are not defined or documented.	Formal NWGs are implemented. The roles and responsibilities are defined and documented. A NWG infrastructure has been implemented by is still in the transitional phase.	Each operator is a member of a NWG. The roles and responsibilities are defined and documented. The NWGs are recognized by the entire organization and have proven to be mature and productive.	
	Observables	No team work activities.	Team activities are realized ***throughout the department***. Those activities are occasional and not formalized.	The NWGs activities are defined and formalized. Business goals are known and reviewed regularly. Most of the NWGs meet regularly and follow up on their activities and results.	All of the NWGs meet regularly. Job functions and NWG members are identified. Roles and responsibilities identified and reviewed at lean annually. All team documentation is maintained in the specific work areas.	

Workplace Organization

Assessment Criteria		Level				Rating
		1	2	3	4	
6. Clear/clean /organized & maintain the production area & office area	Criteria	Numerous unnecessary items clutter the work-place. The workstation has several items that are infrequently used. The team members have no responsibilities to maintain the workplace.	Some items in the work-place are unnecessary. Designated responsibilities have not been determined. Audits are not performed.	Most items at the workstation are used on a frequent basis. WPO tasks/responsibilities are posted. Tasks are not always performed as revealed by the audits.	All items at the workstation are used on a frequent basis. Regular "clear" cycles reveal no unnecessary items. Posted tasks/responsibilities are always performed as revealed by the audits.	
	Observables	There is very little or no designation as to where items belong. The area is dirty. Debris, dirt, and fluid leaks have accumulated over a long period of time.	Aisles, equipment, and material locations are designated. It is difficult to identify proper location of other items in the workplace. The area accumulates debris, dirt, and fluid leaks during working hours but are cleaned up at the end of the shift.	Audits reveal that items are sometimes out of place. WPO task/responsibilities are not always performed.	Audits reveal that items are in their designed place. The area is clean. Causes of debris, dirt, and fluid leaks have been identified and are being addressed. Tasks/responsibilities are posted and performed.	

Workplace Organization (continued)

Assessment Criteria		Level Note: Think Andon				Rating
		1	2	3	4	
7. Visual Controls	Criteria	It is very difficult for an experienced operator to determine the difference between normal and abnormal conditions. Evidence of visual controls is lacking.	Only very experienced individuals can determine the difference between normal and abnormal conditions. Some visual controls are in place.	Individuals that have been trained can determine the difference between normal and abnormal conditions. The ***department*** is in the process of implementing common visual controls.	Anyone can determine the difference between normal and abnormal conditions at a glance. Common visual controls are effectively used throughout the ***department***.	
	Observables	Abnormal conditions are not signaled and/or not responded to. Signals are all manual. Lack of visual controls to support the operator in making decisions.	Abnormal conditions are slow to be signaled and/or response is slow. It takes 5 minutes or more to respond to signals. Operators are reluctant to make decisions because of the lack of visual controls.	Abnormal conditions are signaled after a slight delay and/or response has a slight delay. Signals are responded to in less than 5 minutes. Operators can make decisions with the aid of visual controls, however, are not common from department to department.	Abnormal conditions are quickly signaled and responded to. All signals are automatic. Signals are responded to within seconds. Operators feel comfortable in making decisions with the aid of visual controls which are common from ***department to department***.	

Quality

Assessment Criteria		Level				Rating
		1	2	3	4	
8. Inspection and Test	Criteria	Quality checks are performed off-line (traditional, mass inspection).	Most quality checks are planned for and performed on-line/in-station.	The need for quality checks is reduced due to the efforts of effective process design and use of error proofing. Required quality checks are always performed on-line/in-station.	The need for quality checks has been minimized. Further processing of nonconforming parts is prevented by the use of error proofing and line stops.	
	Observables			Error proofing fixtures/devices are being used. Quality plan in place and accessible. Set-ups verified, e.g., first piece inspection. Quality alert procedure used (if needed)	Customer complaints non-existent or at least minimal and unrelated to error-proofed processes.	

Quality (continued)

Assessment Criteria		Level				Rating
		1	2	3	4	
9. Process Capability	Criteria	Process capability is not measured. Stability of the process is unknown.	Capability of the process is known. Cpk is measured for key characteristics, although < 1.00 on several process (long term study)	For stable and normally distributed data, a Cpk value greater then/equal to 1.33 is achieved for most key characteristics (long-term study).	For stable and normally distributed data, Cpk value greater than/equal to 1.33 is achieved for all key characteristics (long-term study). Focus is on continuous reduction of variation for key characteristics.	
	Observables			Process flow diagrams reference KPCs and KCCs. KPCs, KCCs, and capability study results available. KPCs and KCCs needing attention identified.		

Quality (continued)

Assessment Criteria		Level				Rating
		1	2	3	4	
10. Detect, Solve, and Prevent Quality Problems	Criteria	Key personnel are not trained in problem solving techniques. No disciplined problem solving method in place.	Key personnel are trained in problem solving techniques. Disciplined problem solving method in place but not consistent adhered to. Employee teams (NWGs) work on highly visible problems only.	Disciplined problem solving method is in place and usually adhered to. Employee teams (NWGs) are active problem solving activities. Problem solving is a continuous activity instead of just "fire fighting."	Disciplined problem solving in place and consistently adhered to. Problem solving has transitioned to the Change Methodology (IAPIE) process. Information captured in the DFMEA/PFMEA process and effectively utilized on future products and processes.	
	Observables					

Operational Availability

Assessment Criteria		Level				Rating
		1	2	3	4	
11. Continuous Improvement	Criteria	Basic understanding of operational availability concepts exists, however, the concepts are not applied within the ***department***.	A maintenance data collection process is in for all ***department*** equipment.	A maintenance data collection process is in place. The ***department*** is beginning to use data to determine priorities and solutions to troubles.	Operational availability concepts are well understood and accurate. Data collection and analysis drive continuous improvement.	
	Observables		STDS System is not adequate for job history.	Will have to move to a maximo system to fully implement.	Data files are maintained for all ***department*** equipment to include downtime, number of calls, average repair time, and corrective actions. Data is utilized to develop and implement permanent solutions to troubles.	

Operational Availability (continued)

Assessment Criteria		Level				Rating
		1	2	3	4	
12. Owner Operator	Criteria	The owner operator concept is understood, however, it is not implemented.	Owner operator concept is currently being piloted.	Owner operator concept is use in 50% of the ***departments*** operations.	Owner operator concept is used in 100% of the ***departments*** operations.	
	Observables				Operators monitor machinery to identify problems and perform basic equipment inspection/cleaning. Operators communicate maintenance needs to maintenance. A basic inspection checklist is used. Where appropriate, operators perform/prep for basic repairs.	

Note: To be completed for component departments only.

Assessment Criteria		Level				Rating
		1	2	3	4	
13. Quick Set-up	Criteria	A basic understanding of quick set-up (changeover) exists, however, the concepts are not applied within the ***department***.	The ***department*** is implementing quick set-up process in pilot areas.	Quick set-up procedures has been established on all critic path equipment. Procedures are in place and followed.	Quick set-ups (changeover) are tracked and measured and improvement activities are actively pursued for all multi-product equipment.	
	Observables					

Material Movement

Assessment Criteria		Level				Rating
		1	2	3	4	
14. Container Right Sizing and Supporting the Operator	Criteria	Material is stored on skids or in racks. Operators walk and reach to get parts from containers, having to open packs, dispose of packaging material, and orient parts before being able to use the parts and add value.	Efforts to downsize material and establish standard pack quantities exist. Repacking is being implemented as an intermediary step to containerization.	At least 75% of material is in standard pack quantities and downsized to hand carriable containers. Returnable containers are implemented as warranted. Where containerization is not yet implemented, repacking strategy is utilized.	At least 90% of material is stored in standard pack hand-carriable containers. Returnable containers are implemented as warranted. The operator is presented material in a condition where he/she can immediately add value.	
	Observables					

Material Movement (continued)

Assessment Criteria		Level				Rating
		1	2	3	4	
15. Internal Material Delivery	Criteria	Material is delivered by forklift on patrol. Operators routinely leave their department to pickup their own material.	Material is delivered by forklift or other means based on visual controls to the department. Operators routinely leave their work envelop to pick up their own material.	Material is delivered mainly by flexible delivery devices/tuggers based on pull signals at frequent intervals and on predetermined routes. Operators do not leave their work envelop to pickup material.	The route driver delivers material, and removes empty containers and finished goods directly from the operator's workstation based on pull signals at frequent intervals and on predetermined routes. There is no impact on the operator's work elements.	
	Observables			Standardized work instruction (maps & times) documented for delivery route personnel.		

Employee Environment and Involvement

Assessment Criteria		Level				Rating
		1	2	3	4	
16. Suggestion System	Criteria	Suggestions are not encouraged. Suggestions participation rate is < 20%. Some suggestions are 12 months in age with no response.	A process is in place to encourage individual suggestions. Suggestion participation rate is between 20-55%.	The Suggestion process is efficient and encourages team ideas. Adopted suggestions are implemented within 90 days. Suggestion participation is between 55-90%	Suggestion process time is < 70 days. Documentation supports that the Suggestion System is used and understood. NWG's are fully involved and engaged. Improvements are tracked. Suggestion participation is higher than 90%.	
	Observables				Communication, promotional events & display cases encourage participation. Participation rates, net saving, & submission to closure times reported monthly.	

APPENDIX C

PERCEPTIONS REGARDING THE EFFECTS OF THE IMPLEMENTATION OF LEAN PRODUCTION

Assessment Instrument

PERCEPTIONS REGARDING THE EFFECTS OF THE IMPLEMENTATION OF LEAN PRODUCTION

QUESTIONNAIRE

INTRODUCTION

The purpose of this questionnaire is to collect input from advisors/supervisors and superintendents regarding the effects of the implementation of lean production. Through this questionnaire, we hope to learn more about your opinions regarding these changes and its impact on department performance. **Please answer all of the questions.**

Participation in this survey is <u>entirely voluntary</u>. You may discontinue participation in the survey at any time. You indicate your voluntary agreement to participate by completing and returning this questionnaire. All responses to the questionnaires will be kept strictly confidential. Further, you should not identify yourself on the questionnaire. <u>No one in the Plant will see the completed surveys</u>. Only group statistics and aggregate results will be disclosed as feedback to your plant and all interested employees. The questionnaires will be processed by the researcher alone. <u>Moreover, the questionnaires will be destroyed once the analysis is complete</u>.

The survey data is being collected and analyzed at the School of Labor and Industrial Relations, Michigan State University. Michigan State University will not permit any responses to be traced back to any individuals or allow individuals to be identified in any other way.

Please take the time to complete the survey. **It should take approximately 5-10 minutes to read and complete the survey**.

If you have any questions, please call the researcher Bill Mothersell at (517) 432-0188.

Thank you for your participation.

Department Number: ____________

Please answer each of the following items by circling the appropriate response.

Please answer how the implementation of lean production in your department has improved department effectiveness using the following scale:

To a very little extent						To a very great extent
1	2	3	4	5	6	7

If an item does not apply to your department please leave it blank.

1. The implementation of Lean Production in my department has improved our effectiveness in serving our customers.

To a very little extent						To a very great extent
1	2	3	4	5	6	7

2. The implementation of Lean Production in my department has enhanced our effectiveness in making continuous improvements.

To a very little extent						To a very great extent
1	2	3	4	5	6	7

3. The implementation of Lean Production in my department has enhanced our effectiveness in improving quality.

To a very little extent						To a very great extent
1	2	3	4	5	6	7

4. The implementation of Lean Production in my department has improved our effectiveness in reducing costs.

To a very little extent						To a very great extent
1	2	3	4	5	6	7

5. The implementation of Lean Production in my department has improved our effectiveness in the elimination of waste.

To a very little extent						To a very great extent
1	2	3	4	5	6	7

6. The implementation of Lean Production in my department has enhanced our effectiveness in improving safety.

To a very little extent						To a very great extent
1	2	3	4	5	6	7

7. The implementation of Lean Production in my department has enhanced our effectiveness in improving ergonomics.

To a very little extent						To a very great extent
1	2	3	4	5	6	7

8. The implementation of Lean Production in my department has improved our effectiveness in generating suggestions.

To a very little extent						To a very great extent
1	2	3	4	5	6	7

9. The implementation of Lean Production in my department has improved our effectiveness in implementing suggestions.

To a very little extent						To a very great extent
1	2	3	4	5	6	7

10. The implementation of Lean Production in my department has assisted us in improving our overall performance.

To a very little extent						To a very great extent
1	2	3	4	5	6	7

11. The implementation of Lean Production in my department has improved our effectiveness in solving problems.

To a very little extent						To a very great extent
1	2	3	4	5	6	7

12. The implementation of Lean Production has resulted in our department becoming more integrated and cohesive.

To a very little extent						To a very great extent
1	2	3	4	5	6	7

Thank you for your participation.

APPENDIX D

INTERVIEW PROTOCAL

INTERVIEW PROTOCOL

Plant: ____________________

Name: ____________________

Title: ____________________

Date: ____________________

I am interested in finding out what lean production elements have been implemented in your plant. For each of the following items, please tell me whether these elements of lean production have been implemented in your plant and your assessment of your plant's current position in adapting these lean production elements.

1. Seven types of waste:

2. 5 S (Sort, straighten, sweep, sanitize, sustain):

3. Standardized work:

4. Quick set-up:

5. Small lot (containerization & transportation)

6. Machine layout (decoupling , buffers)

7. Level scheduling and one piece flow:

8. Pull system (kanban):

9. What is your overall assessment of your plant's current position in adopting these lean production elements?

No Implementation	Beginning Implementation	Halfway Implemented	Mostly Implemented	Completely Implemented
0%	25%	50%	75%	100%

Next, I would like to have you consider the plant's activity in the following areas:

10. Involvement and participation (suggestion system, family activities & holiday activities):

11. Teamwork (multifunctional activities, problem solving circles, roles of TM, TL, & TM):

12. Training and development (standardized work, problem solving, TL/TM training):

13. Recognition (attendance, safety, suggestions, etc.)

14. What is your overall assessment of your plant's current position in adopting these lean production elements?

No Implementation	Beginning Implementation	Halfway Implemented	Mostly Implemented	Completely Implemented
0%	25%	50%	75%	100%

APPENDIX E

DEVELOPMENT OF SURVEY ITEMS AND SOURCE FOR PERCEPTIONS REGARDING THE IMPLEMENTATION OF LEAN PRODUCTION

Table 3.6: Development of Survey Items and Source for Perceptions Regarding the Implementation of Lean Production

Construct	Source
Supervisory behaviors	Adapted from Ford, J. Kevin, and Adapted from Cook, Hepworth, Wall & War (1981).
Management support	Adapted from Cook, Hepworth, Wall & War (1981).
Cooperative union-management relations	Adapted from Cook, Hepworth, Wall & War (1981).
Commitment to lean strategy	Adapted from Ford, J. Kevin
Job satisfaction	Adapted from Cook, Hepworth, Wall & War (1981).
Perceived learning environment	Adapted from Tannenbaum, Scott I.
Developmental focus	Developed by William M. Mothersell.
Perceived team performance	Developed by William M. Mothersell
Managing change	Adapted from Ford, J. Kevin
Teamwork	Adapted from Cook, Hepworth, Wall & War (1981).
Involvement/psychological participation	Adapted from Cook, Hepworth, Wall & War (1981).
Process focus	Developed by William M. Mothersell
Proactive problem solving	Adapted from Ford, J. Kevin
Workplace trust	Jointly developed by Ramanand, Moore & Mothersell.
Workplace bonding	Jointly developed by Ramanand, Moore & Mothersell.

Workplace bridging	Jointly developed by Ramanand, Moore & Mothersell
Conflict resolution climate	Adapted from Cook, Hepworth, Wall & War (1981).
Team efficacy	Adapted from Cook, Hepworth, Wall & War (1981).
Lean training	Developed by William M. Mothersell based on training offered in the participating organizations.

APPENDIX F

CORRELATION OF INDEPENDENT, MODERATING, MEDIATING, AND DEPENDENT VARIABLES

Table 4.16

Correlation of Independent, Mediating and Dependent Variables

Variable	1	2	3	4	5	6	7	8	9	10	11
1. People systems composite											
2. Lean training	.23										
3. Technical systems	.13	.42**									
4. Integration (mediation)	-.09	.29*	.87**								
5. Management effectiveness	-.03	.43**	.82**	.73**							
6. Perceived team performance	.64**	-.10	.04	-.20	-.04						
7. Uptime	.16	.05	.32	.36	.54	.03					
8. Suggestion rate	.08	.29	.19	.27	.21	-.20	.42*				
9. Commitment to lean	.50**	.10	.16	.11	.02	.61**	.08	-.15			
10. Job satisfaction	.64**	-.05	-.05	-.23	-.11	.61**	.37	-.09	.37**		
11. Learning environment	.77**	.131	.28*	.10	.15	.42**	.17	-.04	.44**	.60**	
12. Team efficacy	.41**	.16	.17	.03	.05	.22	.11	.10	.00	.14	.25*

Casewise N ranged from 26-69. ** Correlation is significant at .01 level (2-tailed). * Correlation is significant at .05 level (2-tailed).