When does Lean Production Enhance Employee Well-Being? An Analysis Using the Job Demands-Resources Model

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Abstract

Drawing on the job demands-resources (JD-R) model as the theoretical framework, this thesis investigates the effects of lean production on employee wellbeing (measured as work engagement and exhaustion) in a Chinese manufacturer. After qualitative interviews to identify context-specific job characteristics, two sets of survey data were collected from 371 front-line workers and 94 front-line managers respectively, and analysed via structural equation modelling. The results from the worker sample suggest that resources such as relevant training, line-manager support and employee participation in decision-making, along with the challenges posed by problem-solving demands, can enhance employee engagement in the stressful environment of lean production. In contrast, role overload functions as a hindrance demand and poses risks in terms of fostering greater exhaustion and undermining engagement among workers. Two significant interaction effects between job resources and challenge demands are also identified from the worker data in the prediction of work engagement and exhaustion. Similar results emerge from the line manager data in which job resources (training) and job challenges (job complexity) are the main predictors of work engagement whereas job hindrances (role overload) remain the primary determinant of exhaustion. These findings lead to the conclusion that rather than being uniformly positive or negative, the overall impact of lean production on employee wellbeing is likely to depend on the ways in which managers distinguish job challenges from job hindrances and target relevant resources to each of these types of demand. The thesis contributes to the literature by demonstrating how Chinese employees are affected by lean implementation and therefore how managers can enhance employee wellbeing in Chinese enterprises.

Dedicated to the memory of my maternal grandfather

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1. Chapter One: Introduction

The goal of this thesis is to investigate the human consequences of lean production in China and how lean practices can be implemented to the advantage of employee wellbeing. Undertaking this research is important for two reasons. First, existing studies looking into the lean production-to-wellbeing relationship have produced inconsistent results whereby uniformly positive (e.g. Mullarkey, Jackson & Parker, 1995), negative (e.g. Fucini & Fucini, 1990) and a blend of both positive and negative effects (e.g. Anderson-Connolly, Grunberg, Greenberg & Moore, 2002) have all been reported. The negative effect of lean implementation on employee outcomes is particularly salient in the Chinese manufacturing context where heightened work stress, increased work intensity and excessive overtime are frequently reported in the literature (e.g. Brown & O'Rourke, 2007; Zhang, 2015). On the basis of this evidence, Chinese scholars argue that lean production in China is implemented as a system of 'management by stress', which has fuelled a demanding work environment for employees (Zhang, 2015, p. 162). Given evidence of an adverse lean production-to-wellbeing nexus in China and the negative organisational consequences of employee ill-being, such as increased sickness absence and higher labour turnover rates (Spector, 1997), it is high time that research should probe into health-enhancing approaches to lean implementation. The second reason accounting for the significance of the current study is that China makes a huge contribution to world manufacturing output. According to United Nations' calculations, China's share of global manufacturing value-added has increased steadily over time, from approximately eight per cent in 2004 to 25 per cent in 2015 (Levinson, 2017). In the light of China's centrality in global manufacturing and negative employee outcomes under lean production, the predominant manufacturing system adopted in China (Qi, Boyer & Zhao, 2009), it is argued that conducting the current study is important in order to better understand how Chinese employees are affected by lean implementation and therefore how managers can enhance employee wellbeing in Chinese enterprises.

The current chapter starts with a delineation of the theoretical and practical significance of the proposed study. This is followed by an overview of the thesis structure. It is to the theoretic import of the current study that I now turn.

1.1. The Theoretical Significance of the Study

The thesis is inspired by the considerable body of literature on the adverse effects of lean production on employee outcomes, such as work intensification, ill-health and job-related stress (Anderson-Connell et al., 2002; Delbridge, Turnbull, & Wilkinson, 1992; Lewchuck & Robertson, 1996, 1997; Lewchuk, Stewart & Yates, 2001; Parker & Slaughter, 1988). Researchers appear to converge in the belief that the human impact of lean production varies from company to company, depending on the different implementation strategies and choices of specific lean practices applied on the shop floor (Anderson-Connolly et al., 2002; Hasle, 2014; Hasle et al., 2012; Parker, 2003; Koukoulaki, 2014). However, very little prior research has proposed an appropriate lean implementation strategy that can effectively protect employees from lean production-related threats and the associated physiological and psychological costs. To contribute to academic research in this area, the present thesis identified a number of lean-specific job characteristics using the job demands-resources model as a diagnostic tool, and ascertained how each of them impacts on both managerial and non-managerial employees. Making this research effort is important. The reason is that only if the effects of lean characteristics on wellbeing are fully understood, does it then becomes possible to improve employee health by organisations striking a well-matched balance between lean job resources and lean job demands. When this balance is achieved, employees are more likely to take full advantage of the motivational potential of the lean philosophy and at the same time restrain its health-impairing potential.

The current thesis is designed to fill two primary knowledge gaps in lean production research. One is that previous studies investigating the relationship between lean production and wellbeing have been limited in scope with regard to the measurement of lean production characteristics and wellbeing dimensions. For example, the majority of the studies have only investigated the effect of one or two lean practices on a single dimension of wellbeing (e.g. Brenner, Fairris & Ruser, 2004; Guimaraes, 1997; Jackson & Martin, 1996; Karia & Asaari, 2006; Mullarkey, Jackson & Parker, 1995). The other knowledge gap is that prior studies on this topic have predominantly centred on non-supervisory workers, while ignoring the health consequences for line managers under lean settings. This oversight is significant because their attitudes and behaviours are critical in shaping human resource management practices and worker wellbeing (Purcell & Hutchinson, 2007). More importantly, Anderson-Connolly et al.'s (2002) longitudinal study has shown that lean job characteristics such as autonomy and teamwork exert opposite effects on manager and non-manager groups. On the strength of this finding, Hasle (2014) speculated that line managers are likely to experience lean production differently from manual workers because they are often faced with a different set of challenges and demands. This is particularly true in the Chinese context where line managers' 'meat-in-the-sandwich' position can imply a more stressful agenda than that faced either by higher-level managers or by lower-level employees (Huo & Boxall, 2017).

In an interview-based study of 300 employees from the Chinese auto industry, Zhang (2015) found that line managers experience heavier workload and greater strain as a result of cost-cutting, delayering and increased people-management duties in lean settings. The study showed that a large proportion of their time revolves around duties such as training team members in lean activities, conducting performance evaluations and determining bonus distributions. In addition, line managers are frequently forced into direct production, covering for absent workers and helping team members who have difficulties in completing their tasks (Zhang, 2015). In the Chinese context, however, there is an added dimension to these tasks. A line manager's job involves building within-group harmony and showing benevolent concern for employee wellbeing (Cooke, 2012). Being a core value of Confucianism, fostering harmonious interpersonal relationships among team members and mediating intra- and inter-group conflicts are highly important responsibilities for Chinese managers (Zhang, 2015). The significance of this ethic has been reinforced by the Chinese government's policy of Harmonious Society Construction, an initiative launched since 2004 to enhance societal harmony, reduce social conflicts, and strike a balance between different social classes (Wei & Li, 2013). Driven by this governmental policy and the cultural norm of harmony maintenance, Chinese managers attach significant importance to promoting group cohesiveness and tolerating interpersonal disagreement (Leung, Brew, Zhang & Zhang, 2011; Wei & Li, 2013). Efforts targeted at building harmony suggest that Chinese line managers are likely to be susceptible to significant pressure from both their plant managers and their subordinates, leading to heavier workload and greater strain. In Zhang's (2015) study, line managers faced considerable pressures to reconcile the demands of senior managers while responding to the needs of their team members. Based on these results, Zhang (2015) concluded that there is considerable room for improvement in line managers' well-being in China's lean-production plants. Following this line of thought, I believe it is high time that we should build up the body of knowledge on how lean production affects the wellbeing of line managers without whom the lean philosophy cannot be implemented.

In sum, there are two knowledge gaps in the literature on the lean production-to-wellbeing nexus. One is the limited coverage of lean characteristics and wellbeing measures and the other is the omission of the effect of lean implementation on line manager wellbeing. These two knowledge gaps justify the necessity of conducting the present research to comprehensively investigate the relationships of various lean job characteristics with different aspects of wellbeing from both the front-line worker and the line manager perspectives.

1.2. The Practical Significance of the Study

In the current thesis, I decided to examine the human implications of lean implementation in the context of a Chinese manufacturer. I believe that conducting this research in the Chinese manufacturing industry is important and timely for practitioners in light of China's centrality in global manufacturing. Historically, China's low labour costs and strong supply base have made it the manufacturing hub of the world (Hexter & Woetzel, 2007). In 2011, China outperformed the US to become the world's largest manufacturing economy (Eloot, Huang & Lehnich, 2013). To date, China still heavily relies on manufacturing industry to accelerate its economic growth. According to the United Nations (Levinson, 2017), in the year of 2015, the proportion of China's gross domestic product (GDP) represented by manufacturing was 27 per cent. More recently, as new challenges emerge in the Chinese market such as overcapacity across industries and labour costs rise, Chinese manufacturers have realised that they can no longer solely base their cost-saving strategies on rock-bottom worker wages to gain enduring competitive advantages. Instead, more efforts need to be devoted to creating new competitive edges such as developing a wider and more customized range of products, promoting product quality, and enhancing process efficiency (Eloot et al., 2013). To accomplish these objectives, an increasing number of Chinese manufacturers have determined to follow best practices from leading multinationals by implementing lean production programs (Aminpour & Woetzel, 2006). Empirical studies have confirmed the popularity of lean production among Chinese manufacturers. Qi, Boyer and Zhao (2009) carried out a survey investigating the extensiveness of lean implementation in the Chinese manufacturing industry. All of the 604 participating companies came from three economically advanced cities including Beijing, Shanghai and Guangzhou. The results indicated that 285 of the companies (47 per cent) have been applying lean production practices.

Despite the prevalence of lean production among Chinese manufacturers, academic research is scarce examining workers' experiences of lean practices in regard to their working conditions and wellbeing outcomes. A thorough review of the literature only yielded three relevant studies (see Brown & O'Rourke, 2007; Chan, Chen, Xie, Wei & Walker, 2014; Zhang, 2015). To date, what is already known in the literature, based on the few existing studies, is that there are a number of work-related factors in the Chinese manufacturing industry that give rise to a violation of labour rights. For example, occupational health and safety tend to be considered as a low-priority area of labour rights among Chinese manufacturers (Chan et al., 2014). There is a lack of worker representation on the shop floor because workplace unions in socialist countries like China, being financially and politically dependent on the company's administration, do not truly represent and protect workers' welfare and interests (Zhang, 2008). In addition, Chinese workers' awareness of protecting their own workplace wellbeing is low (Chan & Siu, 2012). With these studies in mind, it is conceivable that the above obstacles are likely to expose Chinese workers to increased occupational health and safety hazards.

Indeed, empirical studies looking into the human consequences of lean implementation in China have consistently supported this argument. Based on both interview and survey data collected from workers in a shoe factory adopting lean practices extensively, Brown and O'Rourke (2007) found that, as a result of increased work intensity and reduced job autonomy, workers experienced heightened production pressures and stress. In addition, the rate of work-related injuries was higher than before because front-line operatives had to work longer hours and received inadequate rest breaks under lean settings. Similarly, in a survey of 1,100 autoworkers from twelve lean assembly plants in China, Chan et al. (2014) found that musculoskeletal disorders ('a condition where a part of the musculoskeletal system is injured over time', p. 510) are common among Chinese autoworkers as a consequence of the high production pace and long working hours (on average, survey participants worked 9.2 hours on a normal workday and had 1.7 days off at weekends). Comparable findings were provided by Zhang (2015), who conducted ethnographic research in seven large Chinese auto-assembly plants to examine the human implications of lean production. Drawing on the qualitative data of 300 interviews with workers, managers and union members, Zhang (2015) found that lean implementation had created a more demanding and stressful work condition that forced front-line operatives to work longer and faster, with more pressures and responsibilities but less individual job autonomy. All of these studies clearly indicate that lean workers in China are unlikely to be satisfied with the current state of lean implementation in their companies and that considerable potential for improvement in job design remains. In a word, the pervasiveness of lean implementation among Chinese manufacturers and its negative effects on employee wellbeing outcomes as reported in the literature explain why conducting the current research is important to the business field. China makes an enormously important contribution to world manufacturing output. Therefore, we need a better understanding of how Chinese workers are likely to be affected by lean production if we are to foster employee well-being in Chinese enterprises.

1.3. Overview of the Thesis

This thesis is made up of eight chapters. Chapter two – a review of literature on lean production – defines lean production and employee wellbeing, and describes the fundamental lean principles, specific lean techniques, and the contradictory evidence on the human consequences of lean implementation as reported in previous studies. This chapter concludes by proposing a number of possible reasons to account for those inconsistent findings.

Chapter three introduces the job demands-resources model, which serves as the theoretical rationale for the lean implementation-to-wellbeing relationship. This is followed by a listing of the most prominent job attributes that are characteristic of a lean work environment, and an elaboration on the ten hypotheses regarding how each of these lean-specific job attributes (i.e. job resources, job challenges and job hindrances) affects work engagement and exhaustion.

Chapter four elaborates on the research design and methods applied in the thesis, and justifies each research decision that was made. Specifically, details about the measurement scales, participant population, the process of back translation, procedures of data collection, pilot studies and statistical techniques for data analysis are all reported in this chapter.

Chapter five and chapter six report the data analysis results from the front-line worker and the line manager surveys respectively. This is followed by interpretation and discussion of the survey findings in chapter seven. Finally, chapter eight presents the overall conclusion, reiterating the most significant findings of the study. Additionally, research strengths, limitations and directions for future research are provided. The chapter concludes with a discussion of implications of the current study for both theory and practice.

To sum up, the current thesis mainly adopts a quantitative approach to examining the association between a number of lean-specific job characteristics, on the one hand, and employee exhaustion and work engagement, on the other. A single case study is conducted in a large-scale Chinese manufacturer where two questionnaires are distributed among 371 front-line workers and 94 line managers respectively. Both surveys include multi-item measurement scales for a variety of work characteristics unique to either the line manager or the worker group under the specific lean setting in the prediction of employee wellbeing. In doing so, the current thesis offers a more comprehensive picture of the lean production-to-wellbeing relationship than previous empirical studies have presented.

2. Chapter Two: Literature Review on Lean Production and Employee Wellbeing

The goal of this chapter is to provide an extensive review of studies addressing the definition, underlying guiding principles, operational tools and wellbeing implications of lean production. In addition, plausible explanations are provided as to why prior studies have reported contradictory findings on the relationships between lean implementation and employee outcomes.

2.1. Defining Lean Production

The concept of lean production or lean manufacturing directly derives from, and is frequently used as a synonym for, the Toyota Production System (hereafter TPS) (Womack, Jones, & Roos, 1990). The establishment of the TPS can be attributed to over 50 years' innovative development at Toyota Motor Corporation, which relentlessly sought to remove process variability, and to eliminate waste in the production process (Monden, 1983; Ohno, 1988; Shingo, 1981). After a thorough study of the TPS, Womack and Jones (1996) summarized five core principles of lean philosophy: 1) Specifying value by specific product families; 2) identifying the value stream for each product family; 3) creating continuous production flow without interruptions; 4) letting the customer pull production from the producer; and 5) pursuing perfection. On the basis of these five fundamental lean principles, Suzaki (1987) argued that a truly lean production system continuously seeks to minimize the resources (e.g. manpower, material, time and capital) required to produce goods or services. This is why the term 'lean' is used.

The precise definition of lean production has long been debated in the literature. This lack of clarity is evident from the multiplicity of descriptions and terms used to define lean production (Shah & Ward, 2007). For example, lean production has been referred to as a business management system which is dedicated to minimising waste (Narasimhan, Swink & Kim, 2006), to reducing buffer inventory and system variability (de Treville & Antonakis, 2006), or to one which simply implements certain practices such as just-in-time (JIT) production (Gaither & Frazier, 2002). The only element of consensus is that lean production is a two-dimensional approach to manufacturing (Hasle et al., 2012; Hines, Holweg & Rich, 2004; Pettersen, 2009;

Shah & Ward, 2003, 2007). One dimension is the philosophical perspective associated with the guiding principles and overarching goals of lean production such as waste elimination and continuous improvement (Womack & Jones, 1996; Spear & Bowen, 1999). The other dimension is the operational viewpoint of a set of waste-elimination practices, tools or techniques that can be observed directly such as JIT production and Total Quality Management (hereafter TQM) (Shah & Ward, 2003; Li, Rao, Ragu-Nathan, & Ragu-Nathan, 2005). In line with this two-dimensional perspective of the nature of lean production, the present thesis will employ the most widely accepted definition developed by Shah and Ward (2007). According to them, lean production refers to "an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability" (p. 791). This interpretation is adopted because considering lean production as a combination of both social and technical systems can broaden its focus beyond shop-floor tools to reflect a wider management philosophy which includes both technical practices and human resource management (HRM) practices (Birdi, Clegg, Patterson, Robinson, Stride, Wall, & Wood, 2008; de Menezes, Wood & Gelade, 2010).

Although originally designed for use in manufacturing industry, lean thinking has been operationalised in a variety of ways and applied in an increasing number of other fields, such as the public sector (Kollberg, Dahlgaard & Brehmer, 2006; Pedersen & Huniche, 2011; Radnor, 2010), the construction industry (Jorgensen & Emmitt, 2009; Zimina & Pasquire, 2011) and the aerospace sector (Bamber & Dale, 2000; Comm & Mathaisel, 2000). However, after a review of the studies on the adaptation of lean principles in other sectors, it appears that in the non-manufacturing industry, the application of lean production is still limited and is usually characterised by a partial use of lean techniques and principles, rather than as a complete production system (Bamber, Stanton, Bartram & Ballardie, 2014; Joosten, Bongers, & Janssen, 2009; Marin-Garciaa & Bonavia, 2014). The reason for this is that some lean practices are not appropriate or generalizable to every industry (Lyons, Vidamour, Jain, & Sutherland, 2013; Marodin & Saurin, 2013; White & Prybutok, 2001). It is on the basis of this observation that Liker (2004) concluded that firms applying lean production in its entirety only exist in the auto industry. Given that the use of lean practices in other industries remains selective and partial, the current thesis focuses solely on manufacturing where the adoption of a fuller set of lean principles and practices can be observed.

2.2. Conceptualizing and Measuring Employee Wellbeing

Wellbeing at work is defined as the overall quality of an individual's subjective experience and functioning at work (Warr, 1987). This construct has been measured in the literature using either one or more of its three constituent components including physiological and psychological health, happiness wellbeing and social wellbeing (Grant, Christianson & Price, 2007; van de Voorde, Paauwe & Van Veldhoven, 2013). According to Peccei, van de Voorde and Van Veldhoven (2012), physiological and psychological health can be further broken down into two sub-dimensions, one being negative (e.g. burnout and exhaustion) and the other being positive (e.g. vigour and energy at work). Happiness wellbeing concerns employees' subjective experiences and functioning at work, including such variables as job satisfaction and organisational commitment (Peccei et al., 2012). Social wellbeing refers to the quality of employees' interpersonal relationships with other co-workers or their managers (van de Voorde et al., 2013).

In the current study, employee wellbeing will be operationalised as physiological and psychological health at work. Specifically, work engagement will be adopted as the indicator of the positive sub-dimension whereas exhaustion will be measured as the negative sub-dimension. This decision is made because adopting such a measurement approach is consistent with the literature on the JD-R framework (Demerouti, Bakker, Nachreiner & Schaufeli, 2001; Schaufeli & Bakker, 2004). Doing so enables the comparison of research findings across studies. Work engagement is defined as 'a positive, fulfilling, affective-motivational state of work-related wellbeing' (Leiter & Bakker, 2010, p. 1). Employees who are engaged have high levels of energy and are passionately involved in their work (Bakker, Schaufeli, Leiter & Taris, 2008). According to Schaufeli and Bakker (2004), it consists of three elements including vigour, dedication and absorption. Vigour features high levels of energy and mental resilience at work, the willingness to spend effort in one's work and persistence in difficult situations (Schaufeli, Salanova, Gonzalez-Roma & Bakker, 2002). Dedication is characterised by a high level of job involvement and a sense of significance, enthusiasm, inspiration, pride and challenge (Schaufeli et al., 2002). Absorption refers to being fully concentrated and joyfully immersed in one's job, so that time passes quickly and one has difficulties in detaching oneself from the job (Schaufeli et al., 2002). More recently, the authors of the JD-R model have submitted that it is vigour and dedication that constitute the core of work engagement (Demerouti, Mostert & Bakker, 2010; Salanova & Schaufeli, 2008). Therefore, a number of empirical studies have exclusively focused on these two components when measuring work engagement (see for example Langelaan, Bakker, Van Doornen & Schaufeli, 2006; Llorens, Schaufeli, Bakker & Salanova, 2007; Cullinane, Bosak, Flood & Demerouti, 2014).

As a negative aspect of employee wellbeing, exhaustion refers to the depletion of employees' energy and mental resources as a result of intense and prolonged physical, affective or cognitive strain (Demerouti, Bakker, Nachreiner & Ebbinghaus, 2002). I believe that it is crucial to measure both of the two different dimensions of well-being at work because organisational practices often have mixed impacts on employees, which leads to wellbeing trade-offs, improving one aspect of well-being but jeopardizing another (Grant et al., 2007; Peccei et al., 2012).

2.3. Studying Wellbeing in the Context of Lean Production

The lean production-to-wellbeing relationship has long been a contentious issue in the literature. On the one hand, Womack et al. (1990), the primary proponents of lean production, believe that lean implementation not only leads to improved organisational performance, but also fosters employee wellbeing. Their theoretical reasoning is that the opportunity for workers to develop multiple skills, the increase of job variety within lean teams, and the emphasis on employee involvement in decision-making and problem-solving all contribute to job enrichment and efficiency for lean workers. Therefore, lean production is conceptually believed to be able to reduce the 'mind-numbing stress' characteristic of mass production (Womack et al., 1990, p. 102) and to establish a highly motivating work environment (Adler, 1993a). On the other hand, drawing on research evidence, critics of lean production conclude that lean implementation has a detrimental effect on the quality of working life for employees (e.g. Coles, Lanfranchi, Skalli, & Treble, 2007; Jackson & Mullarkey, 2000; Parker, 2003). Specifically, they argue that lean production is intensified mass production (Tsutsui, 1998). The multiple tasks imposed on workers in lean production represent multitasking rather than multiskilling because they are just variations of similar jobs and little training is required for workers to cope with them (Delbridge, Turnbull, & Wilkinson, 1992). In addition, the degree of employee involvement in organisational decision-making in lean production has been indicated by several researchers as limited (Berggren, 1992; Parker & Slaughter, 1988). Even the teamwork feature of lean production, described positively by advocates, has been criticised as a vehicle for imposing peer pressure to 'facilitate the process of work intensification' (Turnbull, 1988, p. 14). On the basis of these studies, critics of lean production have coined the term 'mean production' or ‘management by stress’ to indicate the negative implications of lean production for employee motivation and health (e.g. Babson, 1993; Delbridge, Turnbull, & Wilkinson, 1992).

This debate over the effect of lean production on wellbeing remains unresolved in existing empirical studies. On the one hand, negative human consequences of lean production have been recorded in qualitative case studies (e.g. Stewart & Garrahan, 1995; Fucini & Fucini, 1990), large-scale surveys (Lewchuk & Robertson, 1996), and comparative studies (e.g. Berggren, 1992; Kaminski, 1996; Klein, 1991). On the other, research-based evidence is also available demonstrating either positive wellbeing implications of lean implementation (e.g. Mullarkey, Jackson, & Parker, 1995; Seppala & Klemola, 2004) or mixed consequences (e.g. Anderson-Connolly et al., 2002; Jackson & Mullarkey, 2000). In an effort to explain these contradictory findings, a new stream of literature has emerged which speculates that lean production is not intrinsically detrimental to employees. Instead, its overall effect depends on the different lean implementation strategies and the choice of specific lean practices being applied on the shop floor (Anderson-Connolly et al., 2002; Conti, Angelis, Cooper, Faragher & Gill, 2006; Hasle, 2014; Koukoulaki, 2014; Parker, 2003). The primary deficiency of this school of literature is that none of these studies has explained why the choice of lean practices matters and what inherent properties of a certain lean practice determine whether the practice is health-enhancing or health-impairing. To date, existing research fails to demonstrate how lean production should be implemented and what lean practices should be adopted so that it can protect employees from work-related threats and the consequent physiological and psychological costs. This research gap justifies the necessity of conducting the current study to identify the beneficial qualities of lean practices and to develop a motivational and health-enhancing approach to lean implementation.

2.4. The Five Lean Production Principles

As was pointed out in the introduction to chapter two, lean production is described in the literature from two perspectives. One is from the philosophical viewpoint associated with guiding principles and overarching goals (e.g. Liker, 2004; Womack & Jones, 1996). The other is from the practical perspective of a set of business practices or techniques that can be observed directly (see for example Shah & Ward, 2003, 2007). In line with the first perspective, this section reviews the five most important lean production principles. Lean-specific techniques and tools that are widely adopted in practice will be discussed in the next section.

Based on a thorough study of the Toyota Production System, Womack and Jones (1996) have identified five core principles that form the basis of the lean production philosophy: 1) specifying value and eliminating waste; 2) identifying the value stream; 3) creating production flow; 4) establishing the pull production process and 5) pursuing perfection via continuous improvement. Lean thinking starts with a precise definition of product value from the customer perspective. The clearly defined product value then facilitates the identification and removal of waste, which refers to all types of activities in the production process that consume job resources but create no value (Womack & Jones, 1996). There are eight forms of non-value-added waste including over-production, waiting time on hand, unnecessary transport or conveyance, over-processing or incorrect processing, excessive inventory, unnecessary movement, defects and unused employee creativity (Liker, 2004). This first principle nicely explains why lean production is 'lean': it provides a way to do more and more with less and less – less human effort, less equipment, less time, and less space – while coming closer and closer to offering customers exactly what they want.

Identifying the entire value stream for each product is the second principle of lean production. The value stream is defined as 'the set of all the specific actions required to design, order and provide a specific product, from concept to launch, order to delivery, and raw material into the hands of the customer' (Womack & Jones, 1996, p. 311). One of the most important reasons for value-stream analysis is to distinguish between value-adding and non-value adding activities so that the latter can be eliminated in order to save production costs.

As the third principle underlying lean production, flow refers to the progressive accomplishment of tasks along the value stream so that a product proceeds from design to launch, order to delivery, and raw material into the hands of the customer with no stoppages, scrap, and backflows (Womack & Jones, 1996). This continuous flow in production can be achieved by eliminating organisational barriers, quickly changing over tools from one product to the next, and applying the full complement of lean techniques. According to Liker (2004), redesigning work processes to attain continuous flow is important for two reasons. One is to minimize the amount of time that any work project is sitting idle or waiting for workers to embark on it. The other reason is that smooth production flow enables the prompt identification and solving of problems.

Using 'pull' systems to avoid overproduction is the fourth lean principle. Its main proposition is that the upstream supplier should provide downstream customers in the production process with what they want, when they want it and in the exact amount they want (Liker, 2004). In a word, nothing should be produced in a ‘pull’ system by suppliers until customers ask them to do so. To achieve this state of ‘just-in-time’ production, work-in-process products and inventory stock have to be minimized.

The fifth principle of lean thinking is pursuing perfection through continuous improvement, which describes the ultimate goal of lean production, namely, the complete elimination of waste so that all of the activities along a value stream create value. In sum, these five principles jointly constitute the core of the lean philosophy. All of the operational lean practices, tools or techniques such as total quality management, just-in-time inventory control and total productive maintenance serve as the means to operationalise these underlying principles.

2.5. The Four Operational Lean Practices and their Impact on Wellbeing

Taking an operational perspective, the current section reviews the literature on the technical tools and practices that constitute lean production, together with their implications for employee wellbeing. In the literature, there are many descriptions and categorisations of the underlying components associated with lean. A likely reason for this phenomenon is that considerable conceptual overlap exists among the various components of lean production, as classified by different researchers (Shah & Ward, 2007). For example, in an effort to conceptualize and measure just-in-time, total quality management and total productive maintenance programs, a large number of researchers have defined leadership commitment, cross-functional training and employee participation as the common elements that are shared by all of the three programs (Ahire, Golhar & Waller, 1996; Powell, 1995; McLachlin, 1997; McKone & Weiss, 1998; McKone, Schroeder & Cua, 1999; Mehra & Inman, 1992; Sakakibara, Flynn & Schroeder, 1993; Saraph, Benson & Schroeder, 1989).

Despite this lack of clarity, I will adopt the most widely agreed-upon classification of the lean techniques endorsed by the majority of scholars, who argue that a lean production system is broadly made up of four complementary subsystems or bundles including just-in-time production (JIT), total quality management (TQM), total productive maintenance (TPM) and lean-specific human resource management (HRM) practices (i.e. work standardisation, team-working, job rotation and employee multi-skilling) (Flynn, Sakakibara & Schroeder, 1995; Longoni, Pagell, Johnston & Veltri, 2013; MacDuffie, 1995; Sakakibara, Flynn, Schroeder &

Morris, 1997; Shah & Ward, 2003; Snell & Dean, 1992). This categorisation is employed for two reasons. First, the four bundles of lean practices fully encompass all of the lean techniques and tools mentioned in the literature. Second, this classification facilitates the discussion of the lean production-to-wellbeing relationship given that different lean practices have different effects on wellbeing, as suggested in the literature (Hasle, 2012; Koukoulaki, 2014).

2.5.1. Just-In-Time Production and its Effect on Wellbeing

To fulfil the lean production principle of waste elimination, Taiichi Ohno, a Toyota production engineer, first coined the term 'JIT' as a manufacturing system for producing and delivering the right items at the right time and in the right amounts (Brown & Mitchell, 1991; Sugimori, Kusunoki, Cho & Uchikawa, 1977; Womack & Jones, 1996). Specifically, the core argument of JIT is that 'in a flow process, the right parts needed in assembly reach the assembly line at the time they are needed and only in the amount needed' (Ohno, 1988, p. 4). Later, Harrison (1992) summarized four essential principles underlying the JIT philosophy: 1) buffer stocks are kept at the lowest possible levels to keep the production line in operation; 2) materials do not enter the production process until the exact time they are required; 3) when a problem occurs in the production process, shop-floor workers should shut down the line to detect and resolve the problem as fast as possible; and 4) production line workers hold responsibility for the quality of the products they produce.

However, meeting these JIT principles may have detrimental effects on worker wellbeing. For example, the reduction in buffer stocks restricts job control and places stress on workers to provide what is required when it is required and at acceptable quality levels (Longoni et al., 2013). As noted by Oliver and Wilkinson (1992), the essence of understanding JIT lies in the recognition that this production system 'dramatically increase[s] the interdependencies between the actors involved in the whole production process, and that these heightened dependencies demand a whole set of supporting conditions if they are to be managed successfully' (p. 68). In addition, the ultimate goal of JIT is the complete elimination of waste and slack. This brings about a reduced cycle time (the time required to complete one cycle of an operation) (Womack et al., 1990). Yet, the occupational safety literature suggests that reducing cycle time leads to increased workloads and work intensity, more repetitive actions and hence an increase in worker effort and stress, all of which may impact on worker health and safety negatively (Landsbergis, Cahill, & Schnall, 1999; Askenazy, 2001). Empirical studies have supported this argument (see for example, Brenner, Fairris & Ruser, 2004; Jackson & Martin, 1996). In a comparative study of a British manufacturing plant with one production line applying JIT and the other undergoing no changes, Jackson and Martin (1996) found that JIT implementation not only led to a decrease in timing control and an increase in production pressure, but also resulted in a reduction in job satisfaction. This observation was explained by the researchers as a consequence of the removal of buffer stocks. Likewise, based on a survey of 1,848 American companies in a cross-section of industries, Brenner et al. (2004) reported that the use of JIT is positively related to employee cumulative trauma disorders (CTD), defined as 'diseases and injuries of the musculoskeletal and nervous systems that are developed gradually over periods of weeks, months or even years as a result of repeated stresses on a particular body part' (US Department of Health and Human Services, 1995, p. 7). They reasoned that JIT systems forbid workers from 'building stocks' so as to secure break times during production. As a result, this shortened period of time for recovery is likely to increase CTDs.

As another mechanism through which JIT brings about negative health outcomes, researchers argue that the removal of slack can evoke role overload, a health-impairing condition that comes into being when workers are tasked with more than they can accomplish in the given time (McLain, 1995; Hofmann & Stetzer 1996). According to McLain (1995), 'safety represents an additional task that can affect performance when the sum of required tasks exceeds attention or performance capacity' (p. 1727). If workers have slack, it is possible for them to pay attention to both safety and productivity, but as slack disappears, workers may take shortcuts and put their own safety in danger. Removing slack, at least when examined on its own, is associated with deteriorated worker wellbeing and safety. This argument has been verified by Pagell, Dibrell, Veltri and Maxwell's (2014) study where 153 lean plant managers from both manufacturing and logistics industries in the US were surveyed. The purpose was to examine how the level of JIT implementation affects worker safety outcomes, as measured by the number of occupational injuries that occurred within the participating organisations. The results of hierarchical regression analyses showed a negative association between JIT practices and worker safety. The reasoning provided by Pagell et al. (2014) was that in order to achieve the JIT objective of waste reduction, organisations tend to cut down system slack. This creates intensified jobs. When workers are overloaded, they are inclined to neglect their own safety at work and not follow the safety production processes. On the basis of the above reasoning and evidence, the majority of researchers agree that JIT practices are detrimental to employee wellbeing.

2.5.2. Total Quality Management and its Implications for Wellbeing

TQM refers to both a philosophy and a set of guiding principles that aim to continuously improve and sustain quality products and processes (Dean & Bowen, 1994; Hackman & Wageman, 1985; Powell, 1995). It is the application of quantitative methods and human resource management practices to improve all the processes within an organisation and exceed customer needs. From a philosophical perspective, TQM advocates the following five concepts: 1) a committed and involved top management team to provide long-term top-to-bottom organisational support; 2) an unwavering focus on both the internal and external customers; 3) effective involvement and utilisation of the entire personnel; 4) continuous improvement of the business and production process; and 5) establishing partnership with suppliers (Besterfield, Besterfield-Michna, Besterfield & Besterfield-Sacre, 1999).

On the basis of this overall philosophy, four fundamental principles are established by lean advocates to guide the implementation of TQM programs. The first is focusing on work processes, because the quality of products and services largely depends on the processes through which they are developed and produced (Juran, 1974; Deming, 1986). To achieve this end, managers are required to train and coach their employees for constantly evaluating, analysing and improving work processes. The second principle of TQM is analysis of variability (Deming, 1986; Hackman & Wageman, 1995). It argues that uncontrolled variability in production processes or outcomes is the root cause of quality problems and thus must be analysed and controlled by workers operating on the front line. Requiring workers to do so encourages them to develop appropriate methods to improve work processes. ‘Management by fact’ is the third principle underlying TQM (Hackman & Wageman, 1995). It requires the utilisation of systematically collected data in every step of the problem-solving process (i.e. from identifying problems, through analysing the root causes, to determining and testing solutions). The fourth principle of TQM is learning and continuous improvement (Dean & Bowen, 1994). It is based on the understanding that the sustainability of TQM entails treating quality improvement as a never-ending pursuit. This is because new and better methods to perform tasks are always possible to be developed. Under such circumstances, a commitment to continuous improvement is crucial to make sure that employees will never stop learning about their work (Hackman & Wageman, 1995).

To practise these principles is to implement a number of constituent techniques under TQM. Overall, the TQM techniques can be divided into two groups – ‘hard’ and ‘soft’ TQM practices (Wilkinson, Marchington & Dale, 1992; Yue, Ooi, & Keong, 2011). The hard aspect of TQM refers to a number of statistical tools to monitor, analyse and improve work processes (Dale, Boarden, & Lascelles, 1994; Guimaraes, 1997; Karia & Asaari, 2006; Kivimaki, Maki, Lindstrom, Alanko, Seitsonen, & Jarvinen, 1997; Morrow, 1997; Ooi, Lee, Chong, & Lin, 2013; Ooi, Bakar, Arumugam, Vellapan, Kim, & Loke, 2007; Wilkinson, Allen, & Snape, 1991; Wilkinson, 1992). For example, two of the most widely applied tools are Pareto analysis and process flow diagrams. Pareto analysis is a diagram that ranks data classifications in descending order from left to right. The data that are classified in the graph can be problems, complaints, causes and types of non-conformities. The value of this graph is that it offers a visual display of the most important characteristics that require attention. Resources are then devoted to correcting the identified problems. Pareto analysis has become a widely used quality improvement tool, for the purposes of problem identification and the measurement of progress. The other popular technique of statistical process control is the process flow diagram. It demonstrates the flow of a product or service as it moves through various processing operations. The diagram makes it easy to visualize the entire system, identifies potential trouble spots, and locates control activities. It also helps employees clarify 'who is the next customer?" By adopting the process flow diagram, the processing procedures can be reduced, combined and removed in order to improve the work processes.

Apart from these technical tools, researchers have identified a number of 'soft' TQM components – a set of HRM-related practices, such as leadership commitment, employee participation in decision-making, cross-functional teamwork, training, and rewards and recognition (Boselie & Wiele, 2002; Dean & Bowen, 1994; Prajogo & Cooper, 2010). Their reasoning is that quality is a product of, and must be driven by, the organisational culture. Organisational culture is the body of values and beliefs shared by all members of an organisation (Kinicki, Scott-Ladd, Perry & Williams, 2015). In an organisational culture that promotes TQM programs, both employees and managers must be intrinsically motivated and determined to provide quality products and services to their customers (Yang, 2006). This is where HRM practices such as empowerment, employee involvement and training play an important role in building a quality-oriented organisational culture and promoting the success of TQM. For example, employee empowerment facilitates continuous process improvement by eliciting the untapped ideas, innovations and creative thoughts from employees (Besterfield et al., 1999). Employee involvement in decision-making improves product quality and increases productivity because employees make better decisions using their expert knowledge of the process. Employees are more likely to implement and support those organisational decisions they played a part in making (Besterfield et al., 1999). In addition, employee involvement increases morale and commitment among the entire personnel by creating a sense of belongingness to the organisation (Besterfield et al., 1999). The provision of total quality training is important so that employees fully appreciate the value of quality and align their personal goals and values with those of TQM (Besterfield et al., 1999). Also, training activities in regard to quality awareness, problem-solving, safety and technical aspects of the job equip employees with knowledge of customer needs and skills for the use of statistical control tools (Besterfield et al., 1999). The above-mentioned reasoning leads to Morrison and Rahim's (1993) conclusion that 'TQM hinges on effective management of human resources and, in this sense, may be viewed as a human resource management (HRM) model' (p. 144).

The literature regarding the impact of TQM on employee wellbeing is made up of two streams. One stream, comprising the majority of empirical studies, looks into the direct relationship between TQM (predominantly measured by its 'soft' components) and wellbeing. In this stream of the literature, a positive association between the two constructs has been consistently reported. For example, in a survey of five public and five private sector organisations in Malaysia, Karia and Asaari (2006) found that the HR elements of TQM (including training and education, empowerment and teamwork) exerted a significant positive influence on employee job involvement, job satisfaction and organisational commitment. As another example supporting the positive TQM-to-wellbeing nexus, Boselie and Wiele (2002) conducted a large survey of 2,313 employees from the Ernst & Young Company in the Netherlands to examine the human consequences of TQM practices (measured by leadership, training, employee participation and customer focus). The survey results showed that all of these constituent practices led to higher levels of employee job satisfaction and less turnover intention. Consistent with these findings, a study of 261 front-line workers in three Serbian manufacturing companies also reported that employee perceptions of TQM implementation (including management commitment, training, teamwork, job evaluation and compensation) were significant predictors of job satisfaction (Arsic, Nikolic, Zivkovic, Urosevic, & Mihajlovic, 2012). Apart from the considerable body of evidence for a positive linkage between TQM and job satisfaction, empirical investigations have also documented the positive effect of TQM on physical health. In a longitudinal research undertaking, Guimaraes (1997) conducted a before-and-after TQM intervention study in a chemical manufacturing plant in the US. A random sample of 73 employees participated in both surveys before and after TQM implementation. The results showed that as a consequence of the introduction of the TQM program, employee perception of job strain had significantly reduced.

The other, but smaller, body of literature examining the TQM-to-wellbeing relationship focuses on identifying the mediation mechanism underlying such a relationship. Along this line, researchers have found an indirect effect of TQM on wellbeing via the mediating role of increased skill utilisation (Lagrosen, Backstrom & Lagrosen, 2010) and skill variety (Carayon, Sainfall, & Smith, 1999; Cooney & Sohal, 2005) – two key wellbeing-enhancing job attributes, as articulated in the job design literature (e.g., Hackman & Oldham, 1976; O'Brien, 1983). One primary reason why TQM facilitates the utilisation of skills is that employees are taught to perform a variety of new tasks, including statistically-based tools (e.g. histograms and Pareto analysis) and quality management activities (e.g. quality inspection and quality record keeping). Engaging in these new tasks enables them to more fully utilise their abilities, training and experience. In addition, TQM requires employees to take direct responsibility for managing manufacturing and service delivery processes to ensure the delivery of quality products or services to customers. Such a delegation of increased responsibility for quality and quality improvement leads to an expansion of employees' work role. This job expansion inevitably requires that employees undertake a greater range of tasks and so skill variety is likely to be broadened (Cooney & Sohal, 2005). According to job design theories (e.g. Hackman & Oldham, 1976; O'Brien, 1982), the increased skill utilisation and variety, as a result of TQM implementation, will further lead to positive employee psychological outcomes such as job satisfaction and work engagement.

Earlier research confirmed the positive relationships between TQM, on the one hand, and skill variety and skill utilisation on the other. In a survey of 424 employees in two public sector organisations in the US, Carayon et al. (1999) found evidence that TQM implementation is a significant predictor of both skill variety and skill utilisation, which in turn contribute to improved quality of working life for employees (measured by job satisfaction, motivation, stress, strain and health). Likewise, Lagrosen et al. (2010) reported similar findings in their case study conducted in a Swedish manufacturing company. From the survey results, the researchers found that TQM implementation (indicated by leadership, employee participation, continuous improvement, customer focus, process orientation and management by facts) is positively related to employee health. Furthermore, they conducted interviews to explore the possible mediators, through which the TQM practices of leadership and employee participation are connected to health outcomes. The qualitative data from the interviews indicated that the variable mediating the positive TQM-to-health nexus is the provision of opportunities for competence development, which maps closely on to the skill utilisation job attribute. Due to the smallness of this body of literature, very few variables (e.g. skill variety) were identified as mediators intervening in the relationship between TQM and employee wellbeing. However, the majority of the literature examining the direct link between TQM and employee outcomes unambiguously reported a positive relationship. It should be noted that these studies largely measure TQM using HRM-related practices only. Therefore, the extent to which the technical tools of TQM such as statistical process control affect wellbeing remains unknown in the literature and merits future investigation.

2.5.3. Total Productive Maintenance and its Impact on Wellbeing

TPM refers to a series of methods to maximize equipment effectiveness via the participation of the entire work force to conduct planned predictive and preventive maintenance of the equipment (Shah & Wall, 2003). There are two primary principles underlying TPM. First, every front-line operative is required to assume the responsibility of cleaning, inspecting and maintaining machinery on a daily basis (Cua, McKone & Schroeder, 2001). Second, all of the employees from managers to workers should be committed to the maintenance process, investing the necessary time and resources in improving machinery performance (Cua, McKone & Schroeder, 2001). The purpose of TPM is to ensure that unexpected breakdowns can be prevented and machines are always able to perform their required tasks so that production is uninterrupted (Womack & Jones, 1996).

The literature on the TPM-to-wellbeing relationship is extremely scant given the fact that only one empirical work is available. Almost all of the TPM-related studies are devoted to understanding its impact on organisational performance (see for example, Cua et al., 2001; Cua, McKone & Schroeder, 2001; Shah & Wall, 2003). This fact indicates a significant research gap regarding the human-side consequences of TPM. From a conceptual perspective, Longoni, Pagell, Johnston and Veltri (2013) believed that TPM should contribute to employee wellbeing. They reasoned that equipment maintenance and clean-up of workstations provide a safer work environment because these activities reduce the rate of machinery breakdowns, leading to a decrease of work-related injuries and accidents associated with equipment breakdowns. Although this statement sounds logical, it was rejected by empirical evidence. By surveying 153 operational managers from a number of manufacturing or logistics companies in the USA, Pagell et al. (2014) found that TPM was not significantly related to the companies' safety performance as measured by the government record of the number and cost of all occupational injuries that occur in the participating companies. Unfortunately, the researchers provided no explanation for this non-significant relationship. To sum up, because of the dearth of studies examining the human implications of TPM, the nature and directionality of this relationship remain unclear in the literature.

2.5.4. HRM Practices under Lean Production and their Association with Wellbeing

Lean-specific HRM practices have been widely recognised by a number of researchers as 'the glue that holds the other lean technical practices together' (MacDuffie, 1995; Cua, McKone, & Schroeder, 2001; de Treville & Antonakis, 2006, p. 102; Longoni et al., 2013, p. 303). The job characteristics model (Hackman & Oldham, 1976, 1980) is relevant to explain the psychological mechanisms through which HRM practices contribute to wellbeing in lean production. According to the model, individual responses to jobs (e.g. job satisfaction and sickness absence) are a function of five core work characteristics, including skill variety, task significance, task identity, feedback and job autonomy. Coming to the lean production context, the presence of these job characteristics depends on the particular lean work organisation practices adopted by the company (Cullinane et al., 2014). If the chosen work organisation practices can foster positive work characteristics such as job autonomy, then improved employee wellbeing will ensue (Parker, 2003). Olivella, Cuatrecasas and Gavlian (2008) have identified four work organisation practices characteristic of lean production that can exert significant impact on employee health-related outcomes. These practices include work standardisation, team-based work organisation, job rotation and multiskilling. Each of these practices has a unique influence on wellbeing and will be elaborated in the following section.

2.5.4.1. Work Standardisation

An essential practice of lean production (Monden, 1983), standardised work refers to 'a precise description of each work activity specifying cycle time, the work sequence of specific tasks, and the minimum inventory of parts on hand needed to conduct the activity' (Womack & Jones, 1996, p. 310). It is characterised by using standard operating procedures and regulations as guidelines to facilitate employees' completion of work tasks (Mehta & Shah, 2005). Work standardisation consists of the specification of three elements: takt time (i.e. the pace of production needed to meet customer demands), the sequence of tasks to be done by each worker (i.e. what is the best way to do the process), and in-process stock (i.e. the maximum inventory). From the employee perspective, critics of lean production point out two primary issues of work standardisation. First, it exerts an adverse effect on employee health. For example, a study conducted by Landsbergis, Cahill and Schnall (1999) indicated that the high level of work standardisation associated with lean production is detrimental to employee health because the reduced work timing control and method control increase work pace and work intensity. Second, given that standardisation specifies tight work rules and principles that do not allow employees to perform tasks according to their own knowledge and methods, Mehta and Shah (2005) believe that work standardisation translates into tight control of workers and jeopardizes job autonomy – a key job characteristic that promotes employee wellbeing (see, for example, Parker & Wall, 1998). As a consequence, higher job strain and dissatisfaction will ensue (Jackson & Mullarkey, 2000).

Two significant research undertakings in the lean production literature provide evidence for the negative relationship between work standardisation and employee outcomes (see Bouville & Valis, 2014; Oudhuis & Tengblad, 2013). In a nationally representative survey study of 24,486 French workers operating under lean production, Bouville and Valis (2014) found that work standardization reduces work autonomy, which leads to worsened employee wellbeing and reduced job satisfaction. Oudhuis and Tengblad (2013) conducted 40 interviews with union representatives and managers at various hierarchical levels from three mechanical engineering companies in Sweden applying lean production. Although the study did not explicitly examine the impact of work standardisation on wellbeing, it revealed that standardised work reduces workers' job autonomy.

However, it should be mentioned at this juncture that, in the non-lean production literature, evidence exists of a positive relationship between work standardisation and wellbeing (e.g. Hsieh & Hsieh, 2003). Two reasons stand out for this positive relationship. First, standardised work promotes the predictability of production processes (Liker, 2004). According to Liker (2004), the most important virtue of standardised work is the maintenance of 'the predictability, regular timing, and regular output of your processes' (p. 38). In doing so, production uncertainty, 'the degree to which a qualified incumbent faces unexpected problems in the course of job performance' (Wright & Cordery, 1999, p. 456), will be decreased. This consequence is significant because, as noted in the job design literature, production uncertainty is one of the most detrimental workplace contingencies that is negatively related to job satisfaction and positively related to job anxiety (Mullarkey, Jackson, Wall, Wilson & Grey-Taylor, 1997; Wright & Cordery, 1999). Second, work standardisation also reduces role ambiguity and improves role clarity (Fisher & Gitelson, 1983; Hsieh & Hsieh, 2001; Jackson & Schuler, 1985). The reasoning is that a high level of work standardisation often implies that employees' work activities are guided by clear and specific rules, policies, and procedures. With this recognition, it logically follows that standardised work can clarify employees' role expectations, which in turn reduces employees' role ambiguity and role conflict and increases job efficiency (Hsieh & Hsieh, 2003). This improved efficiency may lead to employees gaining more rewards in recognition of their performance. As a result, job satisfaction will eventually be enhanced (Hsieh & Hsieh, 2001). This view has been endorsed by Hsieh and Hsieh's (2003) study. Drawing on the survey results of 412 employees from 45 manufacturing and service companies in Taiwan, the researchers identified a negative association between work standardisation and role stress (measured by role ambiguity and role conflict). The explanation for this observation given by the researchers is that standardised work specifies knowledge and methods regarding performance requirements, thereby enabling employees to align their behaviours with those expectations set by the organisation. Under such circumstances, role conflict is less likely to happen. In addition, work standardisation provides employees with information that helps to clarify what is required to fulfil their work goals. A high degree of clarity regarding objectives and procedures for undertaking work activities can effectively reduce role ambiguity.

To sum up, the literature has so far presented both positive and negative findings on the standardized work-to-wellbeing relationship: on the one hand, the majority of studies conducted in lean production settings yield a negative relationship between standard work and employee outcomes. On the other, contrasting evidence in the non-lean literature is available suggesting that some aspects of standardized work are conducive to wellbeing. I argue that one plausible explanation for these contradictory findings lies in the purpose and specific implementation strategies of work standardisation (i.e. mechanistic vs. enabling approaches) adopted by the company. In lean production companies, standardised work is introduced in order to achieve production flow and minimize waste. As Adler, Goldoftas, and Levine (1997) observed, in Toyota's New United Motors Manufacturing Incorporation (NUMMI) plant, front-line operatives followed very detailed standard procedures that touched upon every aspect of the work. Waste was constantly being eliminated to increase productivity. There was strict discipline about time, cost and quality and almost every single minute of the day was structured. Under such circumstances, standardised work tends to be implemented in a mechanistic way that causes work intensification (Koukoulaki, 2014). In contrast, outside the lean production context, standardised work is often implemented in an enabling fashion with the purposes of facilitating work and enhancing role clarity (see, for example, Hsieh & Hsieh, 2003). In this instance, the adoption of standard operating procedures is more likely to be evaluated by workers as a job resource because standardised work offers specific rules and guidance, and clarifies role expectations. This contributes to workers' improved job performance and successful task accomplishment. When this happens, workers are likely to experience increased work motivation and self-efficacy (Oudhuis & Tengblad, 2013), which lead to positive wellbeing outcomes.

2.5.4.2. Team-Based Work Organisation

Work teams are at the core of a lean production plant (Womack et al., 1990; MacDuffie & Pil, 1997). The rationale for introducing the work team is that this form of work organisation is conceptually believed to not only reduce bureaucracy and management layers, but also improve worker performance, as indicated in theories of group effectiveness (Hackman, 1987) and sociotechnical systems (Emery & Trist, 1960; Miller & Rice, 1967; Pearce & Ravlin, 1987). Regarding the relationship between lean production team-work and employee wellbeing, polarised opinions have emerged from the literature. On the one hand, proponents of lean production believe that working in a team places team members in close proximity and therefore they can share issues and provide both resources and social support to each other. When this happens, positive employee consequences such as job satisfaction and reduced stress are likely to ensue (Brenner, Fairris & Ruser, 2004; Conti et al., 2006; Conti & Gill, 1998). Indeed, Conti et al. (2006) found evidence in defence of this argument. Drawing on a large scale, multi-industry survey of lean production organisations, the researchers showed that lean team-working is negatively associated with employee job stress.

On the other hand, a number of empirical studies have reported negative human consequences of team-work under lean settings. These studies include case studies (e.g. Delbridge, Turnbull & Wilkinson, 1992), cross-sectional surveys (e.g. Delbridge, Lowe & Oliver, 2000; Jackson & Mullarkey, 2000) and longitudinal studies (e.g. Parker, 2003; Anderson-Connolly et al., 2002). For example, drawing on the results of various case studies, Delbridge, Turnbull and Wilkinson (1992) found that team-work under lean production offers little job autonomy over the pace of work and task execution. Instead, it is characterised by increased surveillance and monitoring of workers' activities, and a high level of peer pressure, all of which help managers to enhance quality control. The explanation for this phenomenon is that within the lean production context, production processes are deliberately simplified to ensure continuous workflow and work is organised around product groups rather than on a functional basis. Such a plant set-up makes it easier to control material flow and trace defects to individual workers. A dearth of autonomy over work pace and task execution is caused by the use of 'pull' systems and the removal of buffer stocks, which jeopardize team members' ability to stockpile and pause for a break, to hide any defects or to maintain any form of informal control. This is because if one employee stops or slows down, the knock-on effects will be immediate and pervasive in the absence of buffer inventory. Peer pressure as a result of team-work derives from the high degree of work interdependence within lean production teams, which dictates that each team member depends on other co-workers to do the job well. Any failure to supply co-workers with perfect quality products in a just-in-time manner will be noticed immediately with increasingly decreased buffer inventory and thus place a burden on them. Moreover, group pressure can also be imposed on workers through discouraging sickness absenteeism and encouraging working while injured. This has also been supported by empirical evidence. For example, Berggren, Bjorkman and Hollander (1991) in their study of automotive plants in North America reported that there is an organisational climate that encourages working in pain and not reporting injuries as a result of peer pressure. On the basis of these findings, Delbridge et al. (1992) concluded that the situation of teamwork under lean production is such that each worker is constantly governed by fellow teammates in a market-driven production environment. In this manner, each team member plays a control and surveillance role. As a result, lean team members have to perform for, and are controlled by, their co-workers.

Cross-sectional studies have also found support for the negative effect of the lean production team on employee outcomes. For example, in a survey-based study of 556 front-line operators working in lean production teams within a manufacturer of women's clothing, Jackson and Mullarkey (2000) identified the adverse impact of lean team-working on psychological health (measured by job-related anxiety, depression and satisfaction). Such a relationship was found to be mediated by the job design characteristics that were specific to lean teamwork, including a low level of individual timing control, collective method control and group cohesiveness, together with a high degree of problem-solving demands, monitoring demands and production pressure. Likewise, similar findings can be found from Delbridge et al.'s (2000) study based on an international survey of managers from 71 plants in the automotive components industry. The survey results showed limited evidence of job autonomy and increases in technical skills for shop-floor workers as a result of lean production team-working.

The evidence for the negative relationship between lean work teams and employee experiences is also present in longitudinal studies. For example, over a two-year period, Anderson-Connolly et al. (2002) surveyed more than 1,000 employees from a large US manufacturing company. The objective was to examine the relationship between team-work under lean contexts and employee psychological wellbeing (measured by job-related stress and satisfaction) and physical health (measured by behaviours and health symptoms). From the survey, the researchers found that lean teamwork reduces job satisfaction and contributes to worsened health for front-line workers. The explanation given for these observations was that there may be a point at which worker responsibility and accountability in the lean team with complex interdependencies become stress-producing rather than empowering. This speculation is supported by the finding that a significant number of participating employees viewed team-work as a time-consuming organisational fad rather than a helpful avenue for employee involvement. All in all, given the contradictory findings of the relationship between lean team-working and wellbeing, I adopted a contingency view to draw a conclusion about the effect of team-based work organisation in lean settings. Lean team-working is not inherently detrimental to employees. Instead, its effect on wellbeing is contingent on how it is implemented and whether it can truly promote employee work autonomy, participation in decision-making and social support from team members while restraining peer pressure (Koukoulaki, 2014).

2.5.4.3. Job Rotation

Lean production calls for the rotation of workers to ensure that work experience and knowledge is shared throughout the shop-floor and no individual worker gains sole competence in any one area (Delbridge et al., 1992). In the literature, the evidence regarding the human impact of job rotation is polarised. From the supporters' perspective, job rotation is seen as an administrative control designed to reduce ergonomic risks at the lean plant such as work-related injuries (Womack, Armstrong & Likert, 2009; Jorgensen, Davis, Kotowski, Aedla, & Dunning, 2005). For example, to understand how to deal with ergonomic issues under lean manufacturing, Adler, Goldoftas and Levine (1997) conducted a case study examining an ergonomically successful launch of a new truck model in NUMMI – a General Motors-Toyota joint venture. From the study, the researchers identified that the job rotation policy was the key to buffering ergonomic stress by reducing monotony and mitigating repetitive stress risks for difficult jobs. In addition, it was also argued in the study that rotating jobs can help build group cohesiveness, increase task variety and product quality, and contribute to a deeper understanding of the jobs. Moreover, the few survey-based studies on this topic in the non-lean production context report that job rotation increases job satisfaction (Mohr & Zogi, 2008), and reduces both the risk of musculoskeletal disorders (Jorgensen et al., 2005) and the tiredness caused by the over-division of labour (Hsieh & Chao, 2004).

However, criticism of the adverse human consequences of job rotation also exists in the lean production literature. A primary problem associated with this form of work organisation is that the multiple tasks undertaken by workers who rotate their jobs may just be variations of similar work, representing 'multitasking' rather than multiskilling (Delbridge et al., 1992). This is especially the case if workers only rotate within their own team where all of the jobs require similar motions and thus share the same ergonomic risks (Adler et al., 1997). Quantitative studies have supported these arguments. For example, in a survey study of 24,486 French workers operating in lean production systems, Bouville and Valis (2014) reported that job rotation was adversely related to employee job satisfaction, intention to stay and health at work. The reason for these outcomes provided by the researchers is that job rotation is seldom combined with multiskilling (the possibility of performing complex tasks by mobilizing various skills). Instead, the jobs that survey participants undertake during the rotation are characterised by simple motions and repetitive tasks. As a result, the researchers concluded that job rotation has detrimental effects on both employee attitudes and health. Based on the above-mentioned conflicting findings, the conclusion can be drawn that the job rotation-to-wellbeing relationship is also contingent on whether such a practice can genuinely lead to broadened task variety and increased skill utilisation.

2.5.4.4. Employee Multiskilling

Developing employees to master multiple skills is claimed to be a fundamental requirement under lean production because employees in such a context often assume a wider variety of job responsibilities than non-lean workers, such as running multiple machines, conducting equipment maintenance, doing their own quality inspection and solving quality problems (Cua et al., 2001; Forza, 1996; Klein, 1989). In the literature on the job demands-resources model, multiskilling has long been considered as a job resource contributing to work engagement (Bakker & Demerouti, 2014). Moreover, Parker and Wall (1998) argue that increases in skill variety (the degree to which the job requires different skills) lead to employee work motivation and job satisfaction via enhancing their perception of the meaningfulness of the work. This statement is underpinned by the job characteristics model (Hackman & Oldham, 1980), which considers skill variety as one of the five core job characteristics producing either one of the three critical psychological states (experienced meaningfulness of the work, experienced responsibility for outcomes of the work and knowledge of the results of the work activities). In turn, the enhanced critical psychological states will further engender work motivation and job satisfaction. The proponents of lean production believe that a number of lean practices such as cross-training, job rotation, and participative problem-solving facilitate the equipping of workers with greater skill variety (Adler, 1993b; Jackson & Mullarkey, 2000; MacDuffie, 1995; Womack et al., 1990).

However, the critics of lean production do not view the so-called ‘multiskilling’ as a wellbeing-enhancing practice (Delbridge, Turnbull & Wilkinson, 1992; Parker, 2003). The reason is that the multiple tasks performed by employees tend to be variations of similar jobs, representing multitasking rather than multiskilling. Indeed, empirical studies have provided evidence in support of this assertion. For example, Anderson-Connolly et al. (2002) conducted a longitudinal study of 1,000 managerial and manual workers in a large manufacturing company in the USA. The research objective was to examine how different lean practices (e.g. multiskilling and working in teams) influence both the happiness and health-related wellbeing of those involved in the study. The researchers found that multiskilling increases work stress and reduces job satisfaction for non-managerial employees. The explanation for this observation was that learning multiple skills in the case company was perceived by workers as an increased job demand. In view of this finding, I conclude that increases in employee skill variety are positively associated with employee wellbeing provided that the multiple tasks performed by them are truly skill-enhancing rather than just repetitive jobs, representing multitasking.

2.6. Possible Explanations for the Inconsistent Findings in the Literature on the Lean Production-to-Wellbeing Nexus

Overall, the current review of literature on the human implications of lean implementation indicates that the majority of the studies were conducted in manufacturing, particularly the automotive industry. Very few research undertakings were contextualised outside manufacturing. The various studies in the automotive sector predominantly show a negative impact of lean production on both work characteristics and employee wellbeing (e.g. increased job stress and anxiety). In studies from other manufacturing industries, the adverse human consequences of lean production are prevalent but less severe where either no effect (e.g. Mullarkey et al., 1995) or a mixture of both positive and negative effects (e.g. Conti et al., 2006; Jackson & Mullarkey, 2000; Saurin & Ferreira, 2009; Schouteten & Benders, 2004) is reported. I propose five possible reasons that may account for the inconsistent findings in the literature on the lean production-to-wellbeing relationship.

First, multiple descriptions and terms related to lean production have been used in the literature. This is largely attributed to the fact that no uniform definition of lean exists and researchers interpret lean production at their discretion. As a result, making direct comparison of research findings across studies becomes more difficult (Hasle et al., 2012). Second, participants in earlier research worked under different organisational settings. For example, Rinehart, Huxley and Robertson's (1997) study involved workers experiencing a harsh work environment with industrial conflicts whereas Seppala and Klemola's (2004) work targeted employees in a context with a high level of 'respect for human'. According to Anderson-Connolly et al. (2002), the organisation-specific work environment (e.g. economic depression, job insecurity and downsizing) is likely to affect employees’ perception of the effect of lean production on their wellbeing. This argument suggests that findings regarding the lean production-to-wellbeing nexus drawn from previous studies may be confounded by employees’ experience of their work environment.

Third, Hasle et al. (2012) have attributed the contradictory evidence to the question of what comprises lean production in the company under investigation. This argument derives from the observation that the sample companies in previous studies have demonstrated different levels of leanness and varying choices of lean practices being implemented on the shop floor. Given that lean production originated in, and was most applicable to, the auto industry, it is not surprising to find that this industry experiences a higher level of lean implementation and adopts a fuller set of lean principles and practices. In contrast, the application of lean production practices in other industries remains selective and partial (Joosten, Bongers, & Janssen, 2009; Marin-Garciaa & Bonavia, 2014). As suggested in the literature, some non-automotive manufacturing companies implement hybrid forms that incorporate several elements of lean production and other production systems (see, for example, Bayo-Moriones, Bello-Pintado, & Merino-Diaz-de-Cerio, 2010; MacDuffie & Pil, 1995; Snell & Dean, 1992). The reason for this is that not all of the lean tools are generalizable to every industry (Lyons, Vidamour, Jain, & Sutherland, 2013; Marodin & Saurin, 2013; White & Prybutok, 2001). For example, no studies in the service and healthcare industries have reported the utilisation of JIT and TPM programs.

Fourth, Parker (2003) argues that lean manufacturing can have differing effects on job characteristics and wellbeing depending on the different lean practices that are implemented and how they are implemented. For example, in a three-year quasi-experimental study of a manufacturing company, Parker (2003) found that the use of an assembly line was a much stronger predictor of the deteriorated job characteristics and increased job stress and depression, as compared to lean teamwork and workflow formalisation, which were shown to have only moderate negative effects on employee outcomes. As noted in the literature, the lean practices that appear to be the most detrimental to wellbeing are JIT programs, waste elimination and standardised work (Koukoulaki, 2014). The mediation mechanism accounting for this outcome is that these three practices first lead to the deterioration of work characteristics (e.g. reduced job autonomy and increased work intensity), which in turn jeopardise wellbeing. Alternatively, for those lean practices (e.g. training and employee participation in decision-making) that bring about health-enhancing job features such as skill variety and social support, positive employee outcomes are likely to occur (Westgaard & Winkel, 2011). In addition, the configuration of lean production practices the company opts for is also important for employee wellbeing (de Treville & Antonakis, 2006). For example, if a company applies the health-impairing lean techniques to the extreme (JIT and elimination of buffer stocks), while ignoring other wellbeing-protecting tools (e.g. employee involvement and training), this configuration of lean practices leads to the most detrimental consequence for wellbeing.

Apart from the above four reasons provided in the literature to explain the incongruent evidence of the lean production-to-wellbeing nexus, I propose a fifth plausible explanation: the company's objective of introducing lean philosophy is also a determinant of the human implications of lean production because it will affect the choice of techniques companies make in lean implementation. In the automotive industry where most of the negative findings are reported, the main goal for introducing lean practices is concerned with waste elimination and continuous improvement. To achieve this end, companies strive to continuously reduce job resources (e.g. direct and indirect labour, idle time, equipment and raw materials) required to yield a given set of products. Also, the auto companies using lean production aim for achieving extreme leanness via a continuous improvement process. Every improvement in production flow or reduction in waste gives rise to new goals (Womack et al., 1990). This never-ending process brings companies to extreme leanness where employees are increasingly deprived of health-protecting buffers such as job autonomy, idle time and safety inventory. Under such circumstances, work intensity is likely to increase, which further causes deterioration of employee wellbeing. For example, as Adler et al. (1997) have noted, in Toyota's NUMMI plant, front-line workers followed very detailed standard procedures that specify every element of the work. Waste was constantly being eliminated to reduce production cost. When this happens, the effect of lean production on employee outcomes tends to be predominantly negative, such as work intensification and job-related stress (Koukoulaki, 2014).

In contrast, if the primary objectives of lean implementation are work facilitation and encouragement of employee involvement, rather than removal of waste, the impact of lean production on employee outcomes is likely to be positive. For example, Hsieh and Hsieh (2003) surveyed 412 employees from 45 manufacturing and service companies in Taiwan. The results showed that standardised work contributes to reduced role stress (measured by role ambiguity and role conflict). The reasoning provided by the researchers is that work standardisation facilitates employees to successfully complete their job tasks. To elaborate, the standard operating procedures employees are required to follow specify knowledge and methods regarding performance requirements, thereby offering them sufficient information and expertise to accomplish their work easily. As another illustration, in a survey-based study of 525 employees from four non-automotive manufacturing companies in Finland, Seppala and Klemola (2004) found that the use of TQM, JIT and lean teamwork is beneficial for the quality of working life as a result of increased job control and more opportunities for employee participation and learning. The explanation given by the researchers is that the four Finnish companies under investigation have implemented lean production in combination with ideas of sociotechnical systems theory. In doing so, lean implementation brings about more challenging and enriched jobs. The original lean objectives such as production flow and waste elimination are less emphasized in these companies as compared to those in the auto industry.

In sum, the effects of lean production on wellbeing vary from study to study, largely depending on five factors: the definition and measurement of lean production, the organisation-specific working environment, what particular lean techniques are used on the shop floor, how they are implemented and the objectives companies attempt to achieve by introducing lean production.

2.7. The Human Consequences of Lean Implementation in the Chinese Manufacturing Industry

To date, only three empirical studies have been conducted in the Chinese context looking into the lean production-to-wellbeing relationship. All of them uniformly reported negative employee outcomes as a consequence of lean implementation. In a single case study of a shoe factory with extensive usage of lean, Brown and O'Rourke (2007) reported that lean practices led to increased pressure and stress for workers. These negative effects derived from heightened work intensity, reduced timing control and decreased work method autonomy. In addition, the researchers found that lean workers in the case factory worked long hours with inadequate rest breaks, often more than eleven hours a day, six or seven days a week. This work intensification in turn led to higher risks of work-related injuries and ergonomic hazards. Similar findings were also reported in Chan et al.'s (2014) study conducted in the Chinese automotive industry. By surveying more than 1,000 front-line workers from twelve lean assembly plants, Chan et al. (2014) found that the majority of the participants suffered from musculoskeletal disorders as a result of inappropriate setup of workstations, the speedup of the assembly line and long working hours. As a result, 48.3 per cent of the sampled workers reported that, under the present lean work conditions, they felt they would be physically unable to keep working until 40. More recently, Zhang's (2015) ethnographic research in seven large Chinese auto-assembly plants produced comparable findings. Drawing on 300 interviews with workers and managers, she found that the lean, cost-cutting approach created a more stressful working environment, forcing employees to work longer and faster, with greater responsibilities but lower levels of individual autonomy. The deteriorated work condition and the consequent worsened employee wellbeing gave rise to adverse labour relations and worker resistance to lean, which eventually forced management to abandon certain lean practices.

On the basis of these studies, two conclusions can be reached regarding the current state of lean implementation in China and its effect on wellbeing. First, lean production seems to be implemented as a system of 'management by stress', which leads to a more health-impairing and strain-inducing work environment. Under such a production regime, workers are compelled to work longer and faster, with more pressures and responsibilities but little job autonomy at the individual level. Second, because all of the previous studies were based on manual worker groups, they appear to reach a consensus that the health effect of lean manufacturing is largely detrimental for labour workers. However, what is lacking in the lean production literature is studies examining work experiences of Chinese supervisory employees under lean settings. Given the dearth of research undertakings in this respect and the detrimental effect of lean implementation on Chinese workers as identified in the literature, I believe that conducting the current study among both non-managerial and managerial employees is timely and much needed so as to develop a health-enhancing and motivational approach to lean implementation in China.

2.8. Chapter Summary

This chapter has provided a review of extant studies regarding the definition, core principles, operational practices, unique job characteristics and wellbeing implications of lean production. It is worth reiterating two key points from the chapter. First, from a philosophical perspective, lean production is underpinned by five core guiding principles: value specification and waste elimination, value stream identification, creation of production flow, establishment of 'pull' systems and pursuit of perfection through continuous improvement. From a technical perspective, four sets of operational practices (i.e. JIT, TQM, TPM and HRM practices) constitute the lean toolkit designed to operationalise the five principles of lean thinking.

The second key point raised in the current chapter is that the existing studies examining the lean production-to-wellbeing nexus can be grouped into two streams. One stream of literature produced the overall view that lean manufacturing is an inherently harmful production system for employee wellbeing (e.g. Babson, 1993; Delbridge & Turnbull, 1992; Delbridge et al., 2000; Rinehart, Huxley & Robertson, 1997; Lewchuk, Stewart & Yates, 2001). Another school of researchers argued that different lean practices affect employee outcomes differently via the mediating role of work characteristics (e.g. Anderson-Connolly et al. 2002; Conti et al., 2006; Parker, 2003). The general conclusion from this body of literature is that lean production can have mixed impact on wellbeing depending on which specific lean practices are used and how they are implemented on the shop-floor by management. To explain the contradictory literature findings on the lean production-to-wellbeing relationship, I propose in the current thesis that the human implications of lean production vary from company to company, depending on how lean production is defined by the company, what lean techniques are applied on the shop floor, how they are implemented and what are the objectives companies attempt to achieve by introducing a lean philosophy.

3. Chapter Three: Literature Review on the JD-R Model and Hypothesis Development

This chapter first introduces the job demands-resources (JD-R) model as the theoretical foundation underpinning the hypotheses established in the current thesis. This is followed by an elaboration of lean-specific job characteristics that have either positive or negative effects on employee wellbeing. Finally, the ten hypotheses developed in line with the JD-R model are explicated. It is to the propositions of the JD-R model that I now turn.

3.1. Theoretical Framework

In the field of occupational health psychology, several job stress models have been developed to shed light on the relationship between work environment and employee wellbeing (see Cooper, Dewe, & O'Driscoll, 2001). I employ the job demands-resources (JD-R) model as the theoretical framework underpinning the current thesis. The JD-R model is increasingly recognised as a versatile framework for assessing the ways in which management policies and practices, including those associated with HRM, affect employee wellbeing (e.g. Boxall, Guthrie & Paawe, 2016; Conway, Fu, Monks, Alfes & Bailey, 2015; Peccei et al., 2012). Adopting this model is important to help us understand the contradictory findings of earlier studies which reported both positive and negative effects of lean implementation on employees. The most valuable virtue of the JD-R model is that it can accommodate claims raised by both lean proponents and opponents due to its comprehensive consideration of both motivational and health-impairing properties of lean production. The propositions that constitute the core of the JD-R model will be elaborated in the following section.

3.1.1. Job Demands-Resources Model

The JD-R model (Demerouti, Bakker, Nachreiner, & Schaufeli, 2001) is widely utilized in the occupational health literature to predict a variety of wellbeing indicators and organisational outcomes, such as job burnout (e.g. Bakker, Demerouti, & Euwema, 2005; Bakker, Van Emmerik, & Van Riet, 2008), organisational commitment (Bakker, Van Veldhoven, & Xanthopoulou, 2010), work engagement (Bakker, Hakanen, Demerouti, & Xanthopoulou, 2007) and sickness absence (Bakker, Demerouti, De Boer, & Schaufeli, 2003; Clausen, Nielsen, Gomes Carneiro, & Borg, 2012; Schaufeli, Bakker, & Van Rhenen, 2009). The graphical representation of the JD-R model is shown in Figure 3.1, which includes all of its three fundamental propositions. The first proposition in the model is that all types of job characteristics can be classified into either one of the two general categories, namely job demands and job resources. These two distinct sets of job characteristics, which exist across all organizational contexts, are predicted in the model as the primary determinants of exhaustion and work engagement respectively (Schaufeli & Bakker, 2004; Schaufeli, Bakker, & Van Rhenen, 2009).

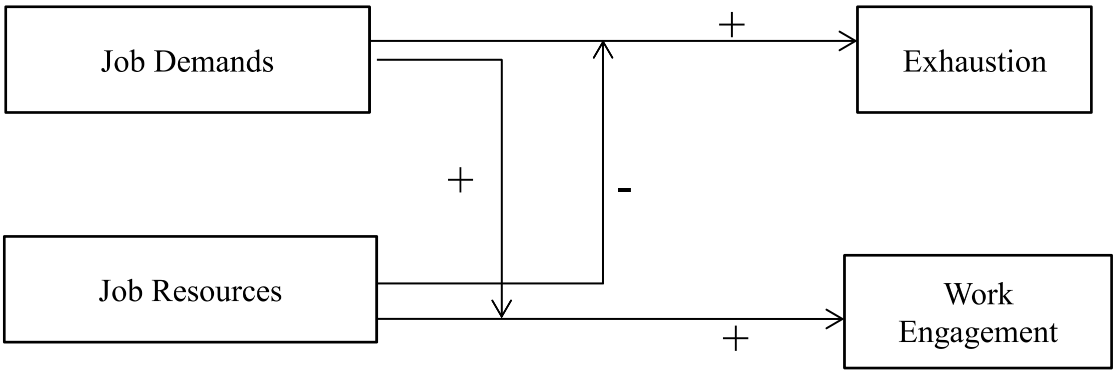


Figure 3.1 The Job Demands-Resources Model. Adapted from Schaufeli and Bakker (2004, p. 297).

3.1.1.1. Defining Job Resources

Job resources refer to ‘physical, psychological, social, or organizational aspects of the job that may do any of the following: 1) be functional in achieving work goals; 2) reduce job demands and the associated physiological and psychological costs; 3) stimulate personal growth and development’ (Demerouti et al., 2001, p. 501). Job resources can take many forms across different levels, such as pay, career opportunities and job security at the organisational level; supervisor and co-worker support at the interpersonal level; role clarity and participation in decision making at the work organisation level; and skill variety, task identity, autonomy and performance feedback at the task level (Bakker & Demerouti, 2007). According to conservation of resources theory (Hobfoll, 2001), the importance of job resources from the employee perspective is two-fold. One is that they are necessary to counteract the negative effect of job demands, the other is that "they are valued in their own right because they are means to the achievement or protection of other valued resources" (Bakker & Demerouti, 2007, p. 312).

3.1.1.2. Defining Job Demands, Job Challenges and Job Hindrances

Job demands are defined as the 'physical, social, or organizational aspects of the job that require sustained physical or mental effort and [are] therefore associated with certain physiological and psychological costs (e.g. exhaustion)' (Demerouti et al., 2001, p. 501). Examples include high levels of work pressure, an unfavourable physical environment, and emotionally demanding interactions with co-workers. More recently, Van den Broeck, De Cuyper, De Witte and Vansteenkiste (2010) suggested that, in light of their opposite effect on work engagement, two distinct sub-categories of job demands should be differentiated, namely job hindrances and job challenges. The former refers to health-impairing job demands that are deemed by employees to be effort-consuming and energy-depleting obstacles to their personal growth, learning and goal accomplishment (Crawford, LePine & Rich, 2010). Examples of job hindrances are role overload, job insecurity and interpersonal conflicts (Cavanaugh, Boswell, Boehling & Boudreau, 2000; LePine, Podsakoff & LePine, 2005). When faced with job hindrances, employees tend to perceive that they are lacking in the capabilities to successfully handle these demands and achieve work goals. As a result, negative emotions will ensue. Because of these negative feelings, employees may be less motivated to apply themselves in the face of hindrance demands and therefore resort to a passive, disengaging style of coping (Crawford et al., 2010). On the basis of this reasoning, researchers have proposed and confirmed a negative hindrances-to-engagement relationship (e.g. Bakker & Sanz-Vergel, 2013; Podsakoff, LePine & LePine, 2007; Van den Broeck et al., 2010).

In comparison, challenge demands are both energy-depleting and stimulating in nature (Van den Broeck et al., 2010). That is to say, although dealing with job challenges also consumes a certain amount of energy, they nevertheless possess inherently motivational properties. The explanation for this argument is that employees view challenges as opportunities to learn, achieve and display the type of competence that tends to earn reward (Crawford et al., 2010). Under such circumstances, they are more willing to put in efforts to cope with challenge demands in the belief that spending their efforts to meet these challenges will bring benefits and gains. The typical job characteristics labelled as 'job challenges' include problem-solving demands, time pressure, and cognitive demands (Cavanaugh et al., 2000; LePine et al., 2005). Because of the motivational quality of challenge demands, Schaufeli and Taris (2014) argue that, as with job resources, this form of job demand is positively related to work engagement. This statement has been supported by empirical studies.

As an illustration, in a meta-analysis of 55 studies, Crawford et al. (2010) found that the relationships between different types of job demands and engagement changed according to the nature of the demand: hindrance demands were negatively associated and challenge demands were positively associated with engagement. Similar results are also derived from Van den Broeck et al.'s (2010) work. By surveying two independent samples of 261 Dutch call centre agents and 441 Belgian police officers, the researchers identified from both populations that job hindrances (measured by negative work-home interference and emotional demands) jeopardized vigour (a core component of engagement) whereas job challenges (reflected by cognitive demands) demonstrated the reversed pattern of relations with vigour. To sum up, the literature has indicated that although both job hindrances and job challenges give rise to exhaustion, they predict engagement in the opposite directions. In view of this reality, I adopt this two-dimensional approach to measuring job demands (i.e. hindrance and challenge demands) in the current thesis.

3.1.1.3. The Health-Impairment Process of the JD-R Model

The second proposition of the JD-R model is that job demands and resources initiate two independent psychological processes for the development of exhaustion and work engagement – a health impairment process and a motivational process (sometimes referred to as 'dual processes' in the literature). That is to say, job demands (including hindrance and challenge demands) are the most significant predictors of exhaustion whereas job resources are the most important determinants of work engagement (Demerouti et al., 2001; Bakker & Demerouti, 2007; Schaufeli & Bakker, 2004; Schaufeli & Taris, 2014). This section deals with the health-impairing process whereas the motivational process will be elaborated in the next section.

The health impairment process argues that energy depletion and health problems occur when job demands increase to the extent that they drain workers' mental and physical resources. The explanation for this effect is that both hindrance demands and challenge demands cost efforts and consume energy (Bakker & Demerouti, 2014). When job demands are high, extra efforts have to be spent to achieve work goals and to keep the performance level from deterioration. This is inevitably accompanied by physical and psychological costs. If employees cannot fully recuperate from these excessive demands, the eventuality is sustained activation and overtaxing, thereby exhausting employees both physically and mentally (Schaufeli & Taris, 2014).

In the lean production literature, a number of job features such as work overload and problem-solving demands, which correspond with hindrance demands and challenge demands respectively as outlined in the JD-R model, have been found to predict ill health (e.g. stress and strain) (Brannmark & Hakansson, 2012; Bouville & Alis, 2014; Mullarkey, Jackson & Parker, 1995; Sim & Chiang, 2013). For example, in their comparison of four Canadian auto companies using lean and non-lean methods, Lewchuk and Robertson (1996) found that, of the 1,600 surveyed front-line operators from sixteen plants, lean workers reported higher levels of workload, which further caused more frequent experiences of job-related stress. Likewise, using two-wave panel data of 1,000 managers and workers from a US manufacturer, Anderson-Connolly et al. (2002) found evidence for the negative impact of work overload on employee health (measured by job stress and health symptoms). These studies, together with the health-impairing process as suggested in the JD-R model, leads to the following hypothesis:

H 1: Lean-specific job hindrances (e.g. role overload) will be positively related to exhaustion.

Problem-solving demands, a form of job challenge as classified in the JD-R model, have also been identified as inhibitors of wellbeing under lean production (Jackson & Mullarkey, 2000; Sprigg & Jackson, 2006). As an illustration, by surveying 242 machinists working in lean teams and 314 machinists in non-lean settings within a British manufacturer of women's clothing, Jackson and Mullarkey (2000) found that the level of problem-solving demands is significantly higher in lean teams and also positively related to job anxiety and depression. Similarly, to investigate the human implications of lean techniques, Bouville and Valis (2014) conducted a nation-wide survey among more than 24,000 French workers of lean production. The survey results showed that problem-solving demands are negatively related to health at work. In view of these studies and the health-impairing process of the JD-R model, I hypothesize the following:

H 2: Lean-specific job challenges (e.g. problem-solving demands) will be positively related to exhaustion.

3.1.1.4. The Motivational Process of the JD-R Model

The motivational process argues that job resources motivate employees to stay engaged (Bakker & Demerouti, 2007; Schaufeli & Taris, 2014). The reasoning for this effect is two-fold. One is that job resources trigger intrinsic motivation by facilitating employee growth, learning and development (Schaufeli & Bakker, 2004). When this happens, employees' basic human needs such as autonomy and competence are fulfilled due to the provision of job resources. As argued by self-determination theory (Deci & Ryan, 1985, 2000), working conditions that promote job autonomy and competence are conducive to increased intrinsic motivation and improved wellbeing. The other reason accounting for the motivational process is that job resources may induce extrinsic motivation by fostering the successful achievement by employees of work goals (Bakker & Demerouti, 2007). This can be explained using the effort-recovery model (Meijman & Mulder, 1998), which argues that an abundance of job resources increases employees' willingness to spend compensatory effort towards the accomplishment of work goals. Under such circumstances, it is likely that job tasks are completed successfully and goals achieved. Under both psychological mechanisms initiated by job resources (i.e. the satisfaction of basic human needs and the facilitation of goal attainment), the outcome is the same – a fulfilling, positive work-related state, which has been labelled 'work engagement' (Schaufeli & Bakker, 2004).

Turning to the lean production literature, a number of job characteristics, although not explicitly referred to as job resources by most of the authors, are shown to promote motivational outcomes of employees in line with the JD-R model. Examples of these job resources characteristic of lean settings are training, performance feedback (Cullinane et al., 2014), social support (Jackson & Mullarkey, 2000) and employee involvement in decision-making (Parker, 2003). For example, in a survey of 200 front-line personnel from a pharmaceutical manufacturer applying lean techniques extensively, Cullinane et al. (2014) measured training and performance feedback as indictors of job resources and found that these two job characteristics were positively related to work engagement. By conducting a quasi-experimental study in a British vehicle manufacturer applying three lean techniques (team-working, assembly lines and workflow formalisation), Parker (2003) found a positive relationship between employee involvement in decision-making and organisational commitment, a construct that shares a high level of conceptual similarity with work engagement (Schaufeli & Bakker, 2010). This discussion gives rise to the following hypothesis:

H 3: Lean-specific job resources (e.g. line manager support, training and employee involvement in decision-making) will be positively related to work engagement.

3.1.1.5. The Cross-Link between Resources and Exhaustion under the JD-R Model

Although not explicitly specified in the original JD-R model, a number of researchers have revised the model by proposing three cross-links between the motivational and health-impairment processes. These cross-linkages are: (1) a lack of job resources predicts exhaustion (Schaufeli & Bakker, 2004); (2) challenge demands are positively related to work engagement (Crawford, LePine & Rich, 2010; Van den Broeck et al., 2010); and (3) hindrance demands are negatively associated with work engagement (Mauno, Kinnunen, & Ruokolainen, 2007; Bakker & Sanz-Vergel, 2013).

In the case of the first postulated cross-link, the rationale derives from the definition of job resources, which are expected to reduce job demands. Following this logic, it is conceivable that a shortage of resources precludes employees from coping effectively with job demands and therefore may lead to exhaustion (Schaufeli & Taris, 2014). Extant literature has supported this statement. For example, by surveying 1,698 employees from four Dutch service companies, Schaufeli and Bakker (2004) tested and confirmed across all sample groups the hypothesis that resources (measured by feedback, social support and supervisor coaching) are negatively related to exhaustion. In the lean production literature, similar findings can be found from Cullinane et al.'s (2014) survey-based study in a British manufacturing company (N = 200). In the study, the researchers showed that three lean-specific resources (i.e. training, performance feedback and job control) are significant predictors of reduced exhaustion. This discussion leads to the hypothesis that:

H 4: Lean-specific job resources will be negatively related to exhaustion.

3.1.1.6. The Cross-Link between Challenge Demands and Engagement under the JD-R model

Regarding the challenges-to-engagement relationship, the directionality as predicted in the literature is such that job challenges are positively associated with work engagement (Crawford et al., 2010; Schaufeli & Taris, 2014; Van den Broeck et al., 2010). This relationship was ascertained based on a large amount of evidence that not all job demands in the JD-R model appear to predict work engagement in the same direction. It is a commonly reported fact in the literature that the job demands-to-engagement correlation is usually statistically non-significant, but occasionally it may also be positive or negative. To explain this ambiguous finding, Crawford et al. (2010) advocated for the discrimination between challenge demands and hindrance demands because, in their meta-analytic study, the former is shown to be positively related to engagement whereas the reverse pattern of relations occurs for the latter. The explanation for the positive challenge-to-engagement relationship is that demands of a challenging nature are positively evaluated by employees as opportunities to learn, attain and display the type of competence that tends to earn rewards. In this instance, employees may be more motivated to invest efforts in coping with challenge demands in the belief that meeting these challenges will bring benefits and gains (Crawford et al., 2010). This reasoning agrees with Schaufeli and Taris (2014), who argue that challenge demands should be conceptualised as a form of resources because they both are motivational in nature and positively valued by employees. Given that very few research undertakings to date have applied the JD-R model in predicting employee wellbeing under lean production, an empirical study from the non-lean context is drawn on to provide evidence for the positive challenges-to-engagement relationship. By surveying 261 Dutch call centre agents and 441 Belgian police officers, Van den Broeck et al. (2010) found in both groups that job challenges (e.g. cognitive demands) are positively related to vigour (a core component of work engagement). In view of both theoretical argument and empirical evidence regarding the relation between challenges and engagement, I posit that:

H 5: Lean-specific job challenges will be positively related to work engagement.

3.1.1.7. The Cross-Link between Hindrance Demands and Engagement under the JD-R model

This cross-link predicts that hindrance demands are negatively related to engagement. It is proposed by Schaufeli and Taris (2014) as a refinement of the JD-R model. This proposition explains the empirical fact in the literature that job demands function differently in the prediction of engagement, depending on the nature of demands. Job hindrances refer to those health-impairing demands that are negatively evaluated by employees as effort-consuming and energy-depleting obstacles to their personal growth, learning and goal accomplishment (Crawford et al., 2010). When faced with job hindrances, employees tend to perceive decreased self-confidence in their capabilities to successfully handle these demands and achieve work goals. As a consequence, negative emotions will ensue. Because of these negative feelings, employees may be less motivated to apply themselves in the face of hindrance demands and therefore resort to a passive, disengaging style of coping (Crawford et al., 2010).

Similar explanation for the negative link between hindrance demands and engagement is provided by the state regulation model of compensatory control (Hockey, 1993; Robert & Hockey, 1997). The primary argument of the model is that ‘the maintenance of performance stability under demanding conditions is an active process under the control of the individual, requiring the management of cognitive resources through the mobilisation of mental effort’ (Robert & Hockey, 1997, p. 78). This illustrates how employees protect themselves from burnout under stressful work conditions, by accepting a decrease in their performance in exchange for no increase in energy and effort expenditure. To elaborate, when job demands are perceived as too high to be met even after they have invested sustained physical or psychological efforts, employees tend to feel that ‘enough is enough’. As a result, they are likely to adopt a passive coping strategy, namely, adjusting their performance targets to a lower level so that no extra effort expenditure is needed. In doing so, the psychological and physiological costs (e.g. fatigue and health symptoms) are prevented but at the cost of deteriorated performance levels. By taking the passive coping mode, especially in the long run, it is likely that disengagement from the pursuit of work goals may result (Schaufeli & Bakker, 2004).

Empirical studies have provided evidence for the negative relationship between hindrance demands and work engagement. In a survey of two Dutch and Flemish samples (N = 702), Van den Broeck et al. (2010) showed that job hindrances (as measured by negative work-home interference and emotional demands) are negatively related to work engagement (as indicated by vigour). This discussion leads to the following hypothesis:

H 6: Lean-specific job hindrances (e.g. role overload) will be negatively related to work engagement.

3.1.1.8. The Interactions between Resources and Demands in Predicting Exhaustion

A third proposition advanced in the JD-R model is that job demands and job resources interact with each other in the prediction of wellbeing. There are two possible ways through which job demands and resources exert a joint effect on wellbeing. One is referred to in the literature as the buffering effect and the other the coping effect. The current section deals with the former interaction: job resources reduce the adverse impact of job demands on exhaustion (Bakker, Demerouti, Taris, Schaufeli & Schreurs, 2003). Theoretically, this contention is originally derived from the job demand-control model (Karasek, 1979), which asserts that job control (a resource) can buffer the detrimental impact of work overload (a demand) on job stress. The rationale for this argument is that workers who have sufficient job resources at their disposal are likely to handle daily job demands better (Bakker & Demerouti, 2014). Extant research undertakings have confirmed this buffering hypothesis for both hindrance and challenge demands. For example, in a survey-based study of 747 Dutch home care workers from two organisations, Xanthopoulou, Bakker, Dollard, Demerouti, Schaufeli, Taris and Schreurs (2007) showed that high hindrance demands (i.e. emotional demands, workload, patient harassment and physical demands) did not lead to increased exhaustion and cynicism under the condition of high job resources, as indicated by autonomy, social support, performance feedback and opportunities for professional development. Similar results can be found in the lean production literature. By surveying 200 front-line operatives in an Irish pharmaceutical manufacturer, Cullinane et al. (2014) found that the positive relationship between challenge demands (production pace, problem-solving and accountability) and exhaustion was weakened when the level of job resources (performance feedback, training and job control) was high. In view of these studies, I postulate that:

H 7: Lean-specific job resources moderate the effect of lean challenge demands on exhaustion such that the effect will be reduced in the presence of high rather than low job resources.

H 8: Lean-specific job resources moderate the effect of lean hindrance demands on exhaustion such that the effect will be reduced in the presence of high rather than low job resources.

3.1.1.9. The Interactions between Resources and Demands in Predicting Engagement

The second interaction between job demands and job resources (i.e. the coping effect) proposed in the JD-R model is that job demands moderate the positive effect of job resources on engagement such that the effect is stronger under the condition of high job demands (including both challenges and hindrances) (Bakker, Hakanen, Demerouti, & Xanthopoulou, 2007; Bakker & Demerouti, 2014). That is, job resources most effectively promote work engagement when job demands are high. This argument finds its theoretical support from the conservation of resources theory (Hobfoll, 2001). According to this theory, people seek to obtain, retain, and protect what they value, such as material, personal, or energetic resources. If this argument holds, job stress experienced by individuals can then be interpreted as potential or actual loss of resources. On the basis of this argument, Hobfoll (2002) proposes that resource gain in itself only has a modest effect on employee well-being, but does have saliency in the context of resource loss. This perspective implies that job resources most strongly predict work engagement when employees are faced with high job demands (Demerouti et al., 2001). Empirical evidence has confirmed this assumption.

Hakanen, Bakker and Demerouti (2005) tested this interaction hypothesis by surveying a sample of 1,919 Finnish dentists. It was posited that job resources (e.g. variability in the required professional skills and positive contacts with patients) promote work engagement especially when job demands are high (e.g. workload and adverse physical work environment). The results of hierarchical regression analysis showed that four out of the 40 tested interaction effects were statistically significant in both subgroups. For example, variability in professional skills (i.e. a job resource) was found to boost work engagement when qualitative workload (challenge demands) was high. Positive patient contacts (i.e. a job resource) enhance dentists' work engagement especially under an adverse physical work environment (i.e. hindrance demands). Likewise, in a survey-based study of 805 Finnish teachers working in elementary, secondary and vocational schools, Bakker, Hakanen, Demerouti, and Xanthopoulou (2007) found that the relationship between job resources (measured by job control, supervisor support, organisational climate, innovativeness and appreciation) and work engagement is strongest when teachers are confronted with high levels of pupil misconduct (the single indicator of job demand). This argument and these empirical studies lead to the following hypotheses:

H 9: Lean-specific job challenges moderate the effect of lean-specific job resources on work engagement such that the effect will be increased given high rather than low job challenges.

H 10: Lean-specific job hindrances moderate the effect of lean-specific job resources on work engagement such that the effect will be increased given high rather than low job hindrances.

3.1.2. Graphic Depiction of the Theoretical Model of the Lean Production-Wellbeing Nexus Hypothesized in the Thesis

The overall theoretical model adopted to predict the lean production-to-wellbeing relationship is shown in Figure 3.2. Drawing heavily on the JD-R framework, the current model argues that lean production can simultaneously induce both positive and adverse effects on different dimensions of wellbeing. This primarily depends on whether employees appraise lean-specific job characteristics as job resources or job demands. To elaborate, some lean job features are found to be detrimental to physical health in the literature, such as role overload and problem-solving demands because they are often perceived by employees as job demands. In contrast, some other lean production work characteristics (e.g. training and management support) are shown to promote wellbeing because employees construe them as resources.

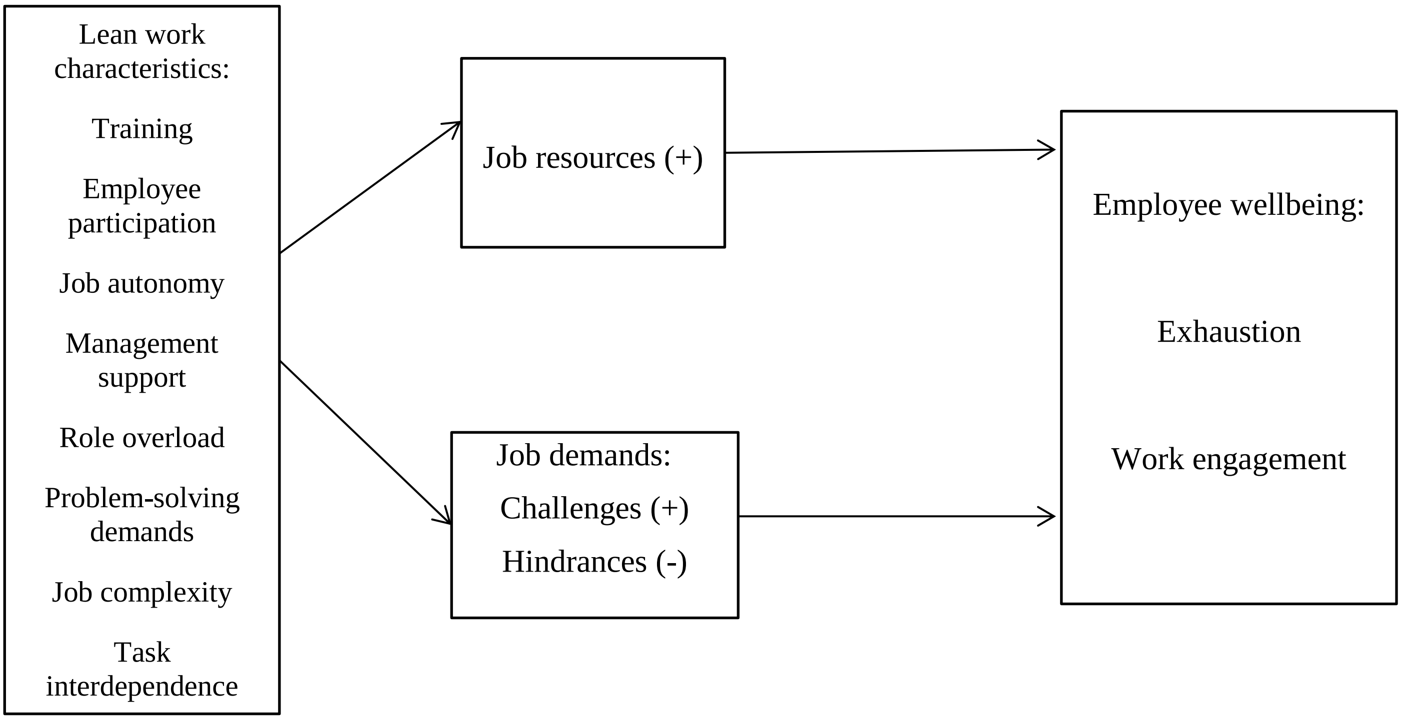


Figure 3.2. The Theoretical Model of the Lean Production-to-Wellbeing Nexus Adopted in the Thesis

3.2. Identifying Lean-Specific Resources, Challenges and Hindrances

Applying the JD-R model in lean production settings requires the identification of specific job resources, job challenges and job hindrances that are characteristic of lean production. Therefore, this section introduces the lean-specific job characteristics that were measured here as predictors of employee wellbeing (i.e. work engagement and exhaustion) in the current thesis. Moreover, how each of these job characteristics is related to employee outcomes as suggested in earlier research will be elaborated.

Derived from an extensive literature review and the findings of interviews with both managerial and non-managerial employees of the case company, eight lean-specific job characteristics were identified as indicators of either job resources, challenge demands or hindrance demands in the prediction of employee wellbeing. Specifically, the provision of training, employee participation in decision-making, job autonomy and management support were proxies of job resources. Problem-solving demands and job complexity reflected challenge demands whereas role overload served as hindrance demands. In addition, a characteristic job attribute under lean settings – task interdependence was included in the current thesis, although its role in predicting employee outcomes remains unclear in the literature. The purpose of including this lean work characteristic was to ascertain the nature and directionality of its relationships with work engagement and exhaustion.

3.2.1. The Provision of Training

Womack et al. (1990) view employee training as a core characteristic of lean production that contributes to the promotion of employee work motivation and physical health. The literature has presented three primary reasons in support of this argument. First, technical training not only broadens employees' knowledge and skills to effectively operate new equipment, but also facilitates their attainment of personal growth and career development (Benson, Finegold & Mohrman, 2004; Marin-Garcia & Bonavia, 2014). These benefits lead to positive employee consequences (Chang, Chiu & Chen, 2010). Empirical studies have frequently observed such a linkage (see for example, Choo & Bowley, 2007; Saks, 1996). As an illustration, using data from the British 2004 Workplace Employment Relations Survey, Jones, Jones, Latreille and Sloane (2009) found that training was positively related to employee job satisfaction. Second, Brown and O'Rourke (2007) argue that the key to improving worker wellbeing in lean production is the provision of occupational safety and health training, informing employees of the hazards of different equipment and the danger of exposure to both chemical and physical agents. This type of training is essential because it enables employees to recognise and control hazards generated in the lean production processes. Third, training in social skills improves employee interpersonal relationships with colleagues thereby facilitating their engagement in more efficient team-work (Kinnie, 1989).

From a theoretical perspective, the JD-R model provides the rationale to account for the important role of lean production training in relation to wellbeing enhancement. As articulated in the model, training can be viewed as a form of job resource that protects employees from the detrimental impact of increased physical and psychological job demands in lean production (Conti et al., 2006). This argument has been supported by Cullinane et al.'s (2014) survey-based study. Drawing on the survey results of 200 employees from a pharmaceutical manufacturing company which adopted lean production extensively, the researchers found that training as an indicator of lean-specific job resources is positively related to work engagement and negatively related to exhaustion. Similarly, a number of studies also provide supporting evidence that training in lean production is positively associated with other wellbeing indicators such as job satisfaction, physical health and safety (Bouville & Alis, 2014; Hiltrop, 1992; Kaminski, 2001; Jacobs, 1995; Longoni, Pagell, Johnston, & Veltri, 2013; Sim, Curatola, & Rogers, 2011). For example, by surveying 184 shop floor workers in a manufacturing company in the USA, Sim et al. (2011) found that training in lean production led to increased worker job satisfaction. They reasoned that training provides the necessary techniques for workers to remain productive and efficient, which subsequently contributes to job satisfaction. Likewise, Kaminski (2001) conducted a quantitative study in 86 small manufacturing firms investigating the effect of training on injury rates. The survey results indicated that training hours were negatively related to the rate of injury. In light of the importance of training under lean settings and the considerable evidence of a positive training-to-wellbeing relationship, the current thesis decided to include it as a job resource under lean production.

3.2.2. Job Autonomy

As a typical form of job resource in the JD-R model literature, work autonomy refers to 'the extent to which a job allows freedom, independence, and discretion to schedule work, make decisions and choose the methods used to perform tasks' (Morgeson & Humphrey, 2006, p. 1323). Two sub-dimensions of job autonomy are the most widely studied in the literature. One is work method autonomy, which refers to the extent to which employees have discretion to choose the procedures of performing tasks (Wall, Corbett, Clegg, Jackson & Martin, 1990). The other is work timing autonomy, defined as the degree to which employees can decide when to carry out the assigned tasks (Wall et al., 1990). The job characteristics model (Hackman & Oldham, 1976, 1980) has long regarded job autonomy as a determinant of employee wellbeing. According to the model, a high level of job autonomy can enhance employee job satisfaction and motivation via its positive effect on an important psychological state – experienced responsibility for outcomes of the work (Hackman & Oldham, 1976). Empirical studies outside the lean production context indeed found that work autonomy is a form of resource, promoting positive attitudinal outcomes of employees (e.g. Bakker, Demerouti & Euwema, 2005; Fried & Ferris, 1987; Parker & Wall, 1998).

Coming back to the lean production literature, the majority of studies indicated that job autonomy is in practice reduced at the front-line worker level (e.g. Delbridge et al., 2000; Jackson & Mullarkey, 2000; Lewchuk & Robertson, 1996; Parker, 2003). For example, drawing on the results from a three year quasi-experimental field study, Parker (2003) found reduced job autonomy for all worker groups exposed to either one of the three lean practices: workflow formalisation, lean team-working and assembly lines. Based on an extensive review of 38 studies examining the human implications of lean production, Landsbergis, Cahill and Schnall (1999) concluded that the high level of work standardisation associated with lean production considerably reduces both timing control and method control. Similarly, Oudhuis and Tengblad (2013) conducted interview-based case studies in three different mechanical engineering companies in Sweden applying lean production. The study indicated that standardised work detrimentally affects job autonomy. This happens because standardisation requires tight work rules and principles that inhibit employee discretion of work methods. Under such circumstances, it is inevitable that work standardisation translates into tight control of workers and jeopardizes job autonomy (Mehta & Shah, 2005). On the ground of these studies reporting a negative influence of lean production on job autonomy for front-line workers, I argue in the current thesis that individual-level work autonomy is rather limited among the non-managerial employee group under lean production.

However, a number of scholars conceptually advance that increased job autonomy should be expected for line managers under lean production via team-level autonomy. The reasoning is that although standardised work reduces work method autonomy at the individual level, other lean practices such as involving employees in continuous improvement and problem-solving groups may foster job autonomy at the team level (Boxall & Winterton, 2015). In addition, as noted by Delbridge et al. (2000), job autonomy at the group level is highly centralised in lean teams. This implies that, as the leader of the work group, line managers have the rights to exercise this increased team-level autonomy. Decision-making authority is likely to be vested in them rather than diffused among the rank and file team members. This statement found its support from Delbridge et al.'s (2000) empirical study. Using survey data of managers from 71 automotive manufacturing plants in nine countries applying lean production, these researchers explored and contrasted the roles and responsibilities of shop-floor operators and line managers. The survey results indicated that line managers assumed considerably more decision-making authority and responsibilities than workers for many shop-floor activities including the allocation and pace of work, production scheduling, problem-solving, process improvement and training. This discussion leads to the conclusion that a higher level of job autonomy may be available for line managers under lean production as a result of greater decentralisation of authority to the team level. If this statement holds, it is logical to further expect that autonomy at work can be used as a lean-specific job resource for the line manager group to improve their wellbeing, as suggested in the JD-R model.

3.2.3. Employee Participation in Organisational Decision-Making

In the general HRM literature, employee involvement in decision-making is widely used as a central explanation for a positive relationship between high performance work systems and wellbeing (see for example, Appelbaum, Bailey, Berg & Kalleberg, 2000; Cappelli & Neumark, 2001; MacDuffie, 1995; Macky & Boxall, 2008). The reason for this is that employee involvement can provide workers with power, information, reward and knowledge (Lawler, 1986, 1992; Vandenberg, Richardson, & Eastman, 1999). The provision of these four factors is reported by a number of studies as conducive to employee wellbeing such as job satisfaction and mental health (e.g. Appelbaum et al, 2000; Mackie, Holahan, & Gottlieb, 2001; Macky & Boxall, 2008; Vanderberg et al., 1999).

Wall, Wood, and Leach (2004) argue for distinguishing between two types of employee involvement practices: role involvement and organisational involvement. The former refers to the delegation of more autonomy and task variety to individual employees for the implementation and management of their own tasks. Examples are job enrichment and autonomous work teams. The latter includes practices ‘that enable employees to have a say in decisions about the management and strategy of their wider organisation’ (Wall et al., 2004, p. 19), such as the design of the production system. Informed by this differentiation between role and organisational involvement, I argue that only the latter can be expected in lean production because of the wide use of quality circle meetings and continuous improvement programs. In contrast, role-level involvement is significantly limited under lean settings as a result of work standardisation and JIT programs. The reasoning is that standardised work requires employee conformity to tight work rules and detailed operating procedures that allow little discretion for them in performing their jobs. Likewise, a JIT approach to controlling inventory minimizes buffer stocks, thereby preventing employees from working ahead or building up stocks. This practice significantly reduces individual autonomy over the production pace, forcing a constant rhythm of work throughout the shop floor (Brenner, Fairris & Ruser, 2004).

Despite the limited role involvement for lean workers, the literature has suggested that encouraging employee involvement at the organisational level is a common practice in lean production for improving employee outcomes (Adler et al., 1997; Forza, 1996; Power & Sohal, 2000; Toralla, Falzon & Morais, 2012). For example, Conti et al. (2006) conducted a survey of 1,391 manufacturing workers in a cross-section of 21 companies with assembly work in the UK. The objective was to investigate the effect of a set of lean production practices on worker job stress. The survey results supported the hypothesis that employee participation in continuous improvement programs contributes to reduced job stress. A plausible explanation for this finding is that involving employees in solving production problems and designing process improvement strategies (i.e. organisational involvement) can create opportunities for influence and learning (Adler, 1993a) – two core job resources in the JD-R model to attenuate the negative impact of job demands.

As another example, in a longitudinal quasi-experimental field study, Parker (2003) identified the mediating effect of participation in decision-making on the relationship between lean practices and health-related wellbeing (measured by job anxiety and job depression). A possible explanation for this mediation effect is that involving employees in the decision-making process enhances job autonomy and skill utilisation. To elaborate, Boxall, Hutchison and Wassenaar (2015) argue that, as a result of employee involvement in decision-making, increased job autonomy enables employees to better cope with demanding work conditions, thereby reducing work-related threats to employee health. Regarding the positive relationship between skill utilisation and wellbeing, Morrison, Cordery, Girardi and Payne (2005) explained that increased skill and knowledge levels enable employees to predict, control, and deal with uncertainty at work, thereby reducing their job strain. To sum up, considering the substantial amount of evidence indicating a positive association between employee involvement in decision-making and health-related outcomes, I argue that this job attribute, as a typical job resource in lean production, is conducive to wellbeing, as suggested by the JD-R model.

3.2.4. Management Support

In this thesis, I conceptualize management support as including two elements, line manager support and top management support to lean production. The former is a job resource uniquely provided to shop-floor workers who report to and interact with their line managers on a daily basis. The latter is a job resource most applicable for the line manager group.

I argue that line manager support is a lean-specific job resource particularly for front-line workers. This statement is supported by empirical studies, which uniformly show that, in lean organisations, supporting workers is an essential part of line managers' job responsibilities (Zhang, 2015). For example, drawing on the survey findings of an international study involving nine countries, Delbridge, Lowe and Oliver (2000) found that line managers in lean production plants were responsible for coaching, training activities and settling of grievances. Similarly, in a case study of shop floor workers from 56 production jobs in a lean auto manufacturer, Womack, Armstrong and Liker (2009) showed that line managers were in charge of reminding workers to undertake tasks in conformity with safety standards, and showing concern for their wellbeing.

The importance of line manager support in promoting employee wellbeing has been empirically verified in the lean production literature. Focusing on three manufacturing plants applying lean production in the USA, Sim and Chiang (2013) surveyed a total of 267 shop floor employees to identify the organisational factors that enhance or undermine successful lean implementation. The survey results indicated that supervisory support is positively associated with employee job satisfaction, and this relationship was mediated by coaching, training and effort-reward equity provided by line managers. On the basis of these findings, the researchers concluded that if 'lean becomes mean' (p. 102), the additional nurturing from managers (e.g. the provision of social support, supervisory coaching and training) can mitigate employee stress and the pressure of overwork. In a quantitative study based on a large-scale, multi-industry survey of lean production organisations, Conti et al. (2006) found that the level of employee stress depends heavily on line management styles in implementing lean production. Likewise, a case study, using New Zealand data, also demonstrated the health-enhancing property of line manager support in lean production. Drawing on interviews data from five managers and 55 front-line workers in a fast-moving consumer goods manufacturer, Sterling and Boxall (2013) found that the extent to which lean production's potential to improve wellbeing can be realised is contingent on how well line managers are developed and supported by the company to foster employee autonomy, skill development and safety. When line managers provide employees with a high degree of job control and adequate opportunities for skill development, the implementation of lean production is likely to be beneficial for wellbeing. Consistent with this finding, a survey of 184 British employees in a lean manufacturing company also reported that perceived supervisory support is positively related to enhanced job satisfaction and effort-reward fairness (Sim, Curatola & Rogers, 2011).

Top management support to lean production is argued in the current thesis as a characteristic job resource most relevant for the line manager group. This can be assumed based on the fact that leadership commitment is a fundamental component of TQM programs. As is widely accepted in the literature, the application of lean production is a strategic decision made from the top. Its successful implementation inevitably requires support from the top leadership team to create and sustain an organisational climate that promotes lean thinking (e.g. Boon, Arumugam & Hwa, 2005; Jun, Cai & Shin, 2006; Lagrosen, Backstrom & Lagrosen, 2010; Ooi, Bakar, Arumugam, Vellapan & Loke, 2007; Ugboro & Obeng, 2000). Empirical studies looking into the human implications of TQM have consistently reported the health-enhancing and motivational properties of top management support. For example, in a questionnaire-based study of 151 front-line operatives in a Swedish manufacturer, Lagrosen et al. (2010) showed that leadership support is a significant predictor of employee physical health. In addition, these researchers found in the follow-up interviews that it is the top managers' qualities of empathy, presence and communication that give rise to this positive effect. Similarly, by surveying 230 workers from a Malaysian semiconductor assembly company with extensive use of TQM, Boon et al. (2005) found that top management support significantly contributes to employees' job involvement, organisational commitment and career satisfaction.

From the theoretical perspective, the job demand-control-support (JDCS) model explains the psychological mechanism through which line manager support and top management support lead to improved employee wellbeing. Building upon the JDC model (Karasek, 1979), Karasek and Theorell (1990) incorporated a social support component into the model as a third fundamental job characteristic that affects wellbeing. A primary proposition of this JDCS model is the moderation hypothesis that social support buffers the negative human impact of high demands and low control. Following this line of argument, it is then safe to conclude that both line manager support and top management support, as a primary form of job resource according to the JD-R model, can lead to positive employee outcomes.

3.2.5. Role Overload

Crawford et al. (2010) define job hindrances as stressful job demands that are evaluated by employees as an inhibitor to their personal growth, learning, and goal accomplishment. This type of job demand is argued in the JD-R literature to jeopardize physical health and reduce work engagement. The reasoning is that when faced with job hindrances, employees perceive a loss of job control and experience negative emotions, which subsequently lower their self-confidence regarding their ability to successfully handle these job demands and achieve work goals. Because of these negative feelings, employees tend to be demotivated to apply themselves in the face of hindrance demands and therefore resort to a passive, disengaging style of coping (Crawford et al., 2010).

Coming back to the lean production context, a number of researchers have shown that role overload is the most prevalent hindrance demand under such settings that is associated with negative wellbeing outcomes (e.g. Brannmark & Hakansson, 2012; Bouville & Alis, 2014; Mullarkey, Jackson & Parker, 1995; Toralla, Falzon & Morais, 2012; Sim & Chiang, 2013). Conceptually, these researchers reason that increased role overload and work intensification are due to the implementation of a number of lean practices, such as reduced cycle time, removal of buffer stocks, standardised work and JIT inventory control, all of which speed up work processes and force workers to do more with less (Graham, 1995; MacDuffie, 1995). Empirical studies have confirmed that work overload is most salient in lean production environments. For example, in their comparison of four Canadian automotive organisations using lean and non-lean methods, Lewchuk and Robertson (1996) found that, of the 1,600 front-line operators sampled from sixteen plants, workers under lean settings reported the highest level of workload and job-related stress. Similarly, in a longitudinal survey of over 1,000 managerial and non-managerial employees from a large US manufacturer, Anderson-Connolly et al. (2002) found that work overload is commonplace in the case company, such as attending more meetings, working overtime and picking up the work of others. In addition, the excessive workload was shown to be significantly related to deteriorated wellbeing outcomes (job-related stress and health symptoms) for both manager and non-manager groups. Based on this observation, Anderson-Connolly et al. (2002) concluded that role overload was the most detrimental dimension of lean production, which predominantly accounted for the negative wellbeing implications of lean production.

3.2.6. Problem-Solving Demands

Cullinane, Bosak, Flood and Demerouti (2013) propose that problem-solving demands is a characteristic job challenge inherent in lean settings that not only costs effort and consumes energy, but also motivates employees via facilitating the satisfaction of their psychological needs. The prevalence of problem-solving demands in lean production has been widely reported in the literature. For example, Hackman and Wageman (1995) argue that the problem-solving teams, which involve cross-functional employees to deal with quality problems at both the intra-departmental and inter-departmental levels, are integral to the TQM program (Hackman & Wageman, 1995). Similarly, in a survey-based study of 70 assembly plants from 24 automotive companies applying lean philosophy, MacDuffie and Pil (1995) found that lean workers on the shop floor are required to assume high responsibilities for problem-solving in order to reduce production uncertainty and variability.

From a theoretical perspective, Jackson and Mullarkey (2000) explained that problem-solving demands are high for lean workers as a result of the elimination of buffer stocks. Under such circumstances, production output is more vulnerable to fluctuation according to the quality of raw materials and variation in workers' task performance. Therefore, in order to maintain the stability of production flow, shop floor workers have to shoulder more responsibilities for anticipating and preventing potential problems that could interrupt production. This statement is echoed by MacDuffie (1995), who argues that 'workers must have both a conceptual grasp of the production process and the analytical skills to identify the root cause of problems' because they are required in lean production environment to 'identify and resolve problems as they appear on the line' (p. 201).

Two empirical studies under lean settings have provided evidence for the health-impairing effect of problem-solving demands. For example, by surveying 242 machinists in lean teams and 314 counterparts in non-lean teams from a British manufacturer of women's clothing, Jackson and Mullarkey (2000) found that the level of problem-solving demands was significantly higher in lean teams and also positively related to job strain (measured by job anxiety and depression). Likewise, in a nationally representative survey of over 24,000 French workers operating in lean production, Bouville and Valis (2014) reported that problem-solving demands were negatively related to health at work. Regarding the motivational properties of problem-solving demands in lean production, no empirical studies have been conducted in this respect. As a result, only the conceptual reasoning by Cullinane et al. (2013) is considered here. According to these researchers, the problem-solving demands in lean settings are of a more challenging nature because they increase employees' utilisation of their skills and tacit knowledge to anticipate and prevent production problems. This heightened use of skills and knowledge in turn induces positive emotions such as work engagement and motivation.

To sum up, considering the definition of job challenges in the JD-R model and the prevalence of problem-solving demands in lean production as suggested by the literature, I argue that problem-solving demands are a unique job challenge in lean settings which may have both health-impairing and motivational effects on employees.

3.2.7. Job Complexity

Job complexity refers to 'the extent to which the tasks on a job are complex and difficult to perform' (Morgeson & Humphrey, 2006, p. 1323). In the lean production literature, empirical studies are extremely scarce in analysing the influence of lean production on job complexity, together with its subsequent implications for employees. Only one research undertaking is available examining how the degree of job complexity is changed after the introduction of lean production. In a survey of plant managers from 203 Spanish plants across various manufacturing industries, Bayo-Moriones et al. (2010) deployed a contingency approach to understanding the impact of lean production (measured by TQM and JIT programs) on job complexity. Specifically, the researchers found that lean implementation exerts an indirect effect on job complexity via its influence on task variety and job autonomy. The form of this mediation is such that lean production gives rise to more complex jobs only if it can promote job autonomy and task variety.

In agreement with this contingency perspective, I argue that lean production leads to increased job complexity only for the line manager group. The reason for this is that, according to the literature (e.g. Cullinane et al., 2013; Delbridge et al., 2000; Hasle, 2014; Scott, Macomber & Ettkin, 1992), line managers in lean production enjoy more job autonomy and greater task variety than workers as a result of the delayering of the supervisory structure and greater decentralisation of authority. In contrast, when considering the front-line worker group, I believe that lean production gives rise to reduced job complexity because of its emphasis on work standardisation. As is shown in the literature, standardized work considerably reduces workers' job autonomy and task variety. For example, using sample data of 823 call handlers from 36 call centres, Sprigg and Jackson (2006) found that adopting the lean practice of dialogue scripting led to reduced job autonomy (timing and method control), and lower task variety. Likewise, by interviewing 40 Swedish managers from three mechanical engineering plants applying lean principles, Oudhuis and Tengblad (2013) found that standardised work reduced workers' job autonomy.

In addition, conceptual studies are in support of this assumption that lean production reduces the level of job complexity for front-line workers. For example, Genaidy and Karwoski (2003) argue that, in JIT work settings, jobs are made up of simple tasks that not only require little physical task exertion but also pose fewer cognitive demands to incumbents. I believe this perspective is reasonable considering the task-simplifying property of a number of operational lean practices. For example, as a result of work standardisation, employees' work activities are guided by clear and specific rules, procedures and policies. When this happens, their jobs are likely to be less complex because the standard operating procedures bring about the simplification of work methods, the clarity of job roles and the predictability of production processes (Liker, 2004). This agrees with Delbrige, Turnbull and Wilkinson (1992), who argued that within lean settings, production processes are deliberately simplified in order to accomplish continuous workflow – a fundamental principle of lean production. Likewise, a number of researchers have reported that, although widely practiced in lean production, job rotation does not appear to enlarge employees' skill repertoire. The reason for this is that the multiple tasks undertaken by workers who rotate their jobs are just variations of similar work, representing multi-tasking rather than multi-skilling (Delbridge et al., 1992). This is especially true when workers only rotate within their own team where all jobs require similar motions (Adler et al., 1997). Bouville and Valis's (2014) survey results from 24,000 French lean workers confirmed the hypothesis that job rotation is seldom combined with multiskilling because all of the activities workers undertake during the rotation are characterised by simple motions and repetitive tasks.

Regarding the effect of job complexity on employee outcomes, the JD-R model literature classifies job complexity as a challenge demand which is predicted to have both health-impairing and motivational effects on employees (Crawford et al., 2010). This is because undertaking complex work not only costs effort and energy, but also requires the utilisation of multiple skills related to mental processes, contextual knowledge and technical knowledge of the work tasks. Further, this increased cognitive demand is likely to produce positive motivational outcomes (Dean & Snell, 1991; Morgeson & Humphrey, 2006). In line with this argument, I include job complexity in the current thesis as a proxy of challenge demand, but only for the line manager group.

3.2.8. Task Interdependence

To date, most of the studies addressing the human implications of lean manufacturing have largely been centred on the work features identified in the job characteristics model such as job autonomy and skill variety (e.g. Anderson-Connolly et al., 2002; Jackson & Mullarkey, 2000; Parker, 2003; Sprigg & Jackson, 2006). However, Wall and Jackson (1995) argue that task interdependence is an equally important work characteristic to consider. Interdependence is defined as the extent to which employees need to cooperate with, and are dependent on, each other to make a product or deliver a service (Cumming & Blumberg, 1987). Low task interdependence indicates that there is little need for collaboration whereas high interdependence implies that employees have to coordinate and share information to get their interrelated work done (Parker & Wall, 1998). The current thesis argues that in the lean production context the degree of task interdependence is particularly high. This is the consequence of the implementation of two fundamental lean practices, team-based work organisation and JIT production. As noted by Cummings and Blumberg (1987), having an interdependent set of tasks has long been regarded as an important prerequisite for team-based work. In addition, a fundamental requirement of JIT programs is the removal of buffer stocks between processes so that the right items are delivered to the assembly line at the right time and in the right amounts (Brown & Mitchell, 1991; Womack & Jones, 1996). This implies that every worker's activities have to be more closely coordinated than in previous mass production (Hiltrop, 1992). Also, the lean principle of promoting participative work design shapes the shop-floor settings into multidisciplinary production units within which all activities are oriented towards the production of a single product. Under such circumstances, employees tend to be dependent on one another's skills and manpower for completing the work (Cullinane et al., 2014). In light of the above arguments and evidence, it is reasonable to reach the conclusion that task interdependence is a job attribute characteristic of the lean production process.

The literature examining the task interdependence-to-wellbeing relationship is rather sparse. Only three empirical studies have been conducted, yielding contradictory findings. To elaborate, based on a survey of 188 employees from 67 occupations within an American university, Wong and Campion (1991) found that task interdependence was a significant predictor of job motivation. The explanation provided by the researchers was that task interdependence was positively related to three motivational job characteristics including feedback, job variety and task identity. They reasoned that when tasks are interrelated, the quality of one's performance on some tasks is likely to be clearly manifested because his/her output is immediately needed by co-workers to perform other tasks. As a result, job feedback is likely to increase when the outputs of some tasks are the inputs of other tasks. Interdependent tasks may require more coordination and therefore involve activities such as planning, scheduling and inspection, which further lead to the broadening of employee job variety. Task identity may also increase because the interdependence among different tasks enables employees to see better how their individual task contributes to the whole product.

In contrast, in a survey of 200 employees from an Irish pharmaceutical company with extensive lean practice usage, Cullinane et al. (2014) classified task interdependence as a form of job demand and found a positive association with exhaustion. Because the literature has presented inconsistent findings of the task interdependence-to-wellbeing relationship, it is difficult to clearly conclude whether task interdependence is a form of job resource or job demand. To answer this question, Sprigg, Jackson and Parker's (2000) perspective is worth considering. According to these researchers, task interdependence is a characteristic of the production process and its impact on employee wellbeing depends on whether it fits with other work design characteristics of the company (e.g. team working and the level of job autonomy). By surveying 231 front-line operatives from wire-mills and roperies that both adopted team-based work organisation, Sprigg et al. (2000) investigated how work design characteristics (i.e. teamwork and job autonomy) affect employee wellbeing (measured by job satisfaction and strain). The primary finding was the need for a contingency approach to understanding the consequences of work design, such that the same job characteristic would have different impacts on employees depending on the degree of task interdependence. This was evidenced by the observation that workers in roperies had higher levels of job satisfaction and lower levels of job strain compared to their counterparts in wire-mills. The explanation for this fact was that the nature of high task interdependence in the rope-making process is well suited to team-based work design. In contrast, the wire-making process has a low level of task interdependence, and thus requires workers to operate independently. Under such circumstances, team-based work organisation became an inhibitor to employees' work activities. In addition, the survey results showed a significant interaction effect between task interdependence and individual job autonomy in predicting job strain. The form of this moderation is that job control reduced strain only under the condition of low task interdependence. The reasoning provided by the researchers was that job demands in low-interdependence jobs tend to affect incumbents individually. The job resources expected from workers to cope with these demands are likely to be at the individual level such as individual autonomy. With this recognition, it follows that, for a job which requires little task interdependence, one would expect that many of the job demands and problems encountered by workers could be dealt with by themselves independently. Under such circumstances, giving the job holder greater individual autonomy is useful to facilitate his/her successful coping with the specific demands of that work setting. By contrast, in a job of high task-interdependence, providing workers with individual autonomy is unlikely to be effective in helping them handle work demands, which often have a more widespread impact and require more than one person to manage. In this instance, individual job autonomy will be counterproductive because workers need to have influence over other team members' actions in order to cope with demands effectively.

In line with Sprigg et al.'s (2000) contingency view to understanding the task interdependence-to-wellbeing relationship, I argue in the current thesis that the high level of task interdependence in lean settings, when examined by itself, is neutral in the prediction of employee outcomes. That is, it neither promotes nor jeopardizes wellbeing directly. Instead, its impact on wellbeing is contingent on the extent to which it fits with other job design characteristics in the company.

To sum up, after a careful study of the literature, seven job characteristics relevant to the lean production context have been identified and will be used in the current thesis as indicators for either job resources, challenges or hindrances in the prediction of employee wellbeing. Specifically, the provision of training, job autonomy, employee involvement in decision-making and management support will be utilised as proxies of lean-specific job resources. Role overload will serve the role of lean-specific job hindrances whereas problem-solving demands and job complexity will be adopted as indicators for lean-specific job challenges. In addition, despite its ambiguous relationships with health-related outcomes, task interdependence, a work characteristic unique to lean settings, will also be included in the current thesis. The purpose is to ascertain how it should be categorized in relation to the job demand-job resource taxonomy.

3.3. Chapter Summary

This chapter has introduced the JD-R model as the theoretical framework of the study and proposed ten corresponding hypotheses associated with the lean-characteristics-to-wellbeing nexus. To elaborate, the JD-R model classifies all work characteristics into either one of three groups – job resources, challenge demands and hindrance demands, which activate either health-impairing or motivational processes to predict employee outcomes such as exhaustion and work engagement. In accordance with the propositions as outlined in the JD-R model, the following hypotheses relevant to the lean production context were developed:

H 1: Lean-specific job hindrances (e.g. role overload) will be positively related to exhaustion.

H 2: Lean-specific job challenges (e.g. problem-solving demands) will be positively related to exhaustion.

H 3: Lean-specific job resources (e.g. line manager support, training and employee involvement in decision-making) will be positively related to work engagement.

H 4: Lean-specific job resources will be negatively related to exhaustion.

H 5: Lean-specific job challenges will be positively related to work engagement.

H 6: Lean-specific job hindrances will be negatively related to work engagement.

H 7: Lean-specific job resources moderate the effect of lean challenge demands on exhaustion such that the effect will be reduced in the presence of high rather than low job resources.

H 8: Lean-specific job resources moderate the effect of lean hindrance demands on exhaustion such that the effect will be reduced in the presence of high rather than low job resources.

H 9: Lean-specific job challenges moderate the effect of lean-specific job resources on work engagement such that the effect will be increased given high rather than low job challenges.

H 10: Lean-specific job hindrances moderate the effect of lean-specific job resources on work engagement such that the effect will be increased given high rather than low job hindrances.

4. Chapter Four: Research Design and Methods

This chapter provides an overview of the research design and methods. Specifically, the research design, the data-collection instruments, the sample populations, the data-collection procedures, the measurement scales, the survey-translation processes, the pilot study and the data analysis techniques will be described in turn. The chapter begins by justifying the fundamental research decision – why a quantitative method based on questionnaire surveys was adopted rather than a qualitative approach.

4.1. Quantitative or Qualitative Research?

Considering the explanatory nature of the current study, I decided to employ a survey-based research design in a single case study. It is a quantitative approach in which the investigator 'samples a population within a case and uses questionnaires to ask questions regarding a topic or issue in order to describe population trends or to test hypotheses' (Chmiliar, 2010, p. 125). The quantitative approach was adopted here for two reasons. First, it has been the predominant method used in previous studies to examine the impact of lean implementation on employee health (e.g. Babson, 1993; Brenner, Fairris & Ruser, 2004; Bruno & Jordan, 1999; Bouville & Alis, 2014; Cullinane et al., 2014; Jackson & Martin, 1996; Parker, 2003; Power & Sohal, 2000; Stewart & Garrahan, 1995). As was shown in chapter two, the majority of studies in the literature on the lean production-to-wellbeing relationship rely on quantitative measures of both lean practices and employee health. With this recognition, I believe that the research method used in the current study should be consistent with previous studies so as to engage with the research debate and add value to this body of literature. The second reason why a quantitative approach is used here is that one of the objectives of the present study is to examine the applicability and validity of the JD-R theory in a new research population. The theory was originally developed using a research design based on self-completion survey data (see Demerouti, Bakker, Nachreiner & Schaufeli, 2001). This has continued to be the exclusive research method adopted by all of the existing studies under the JD-R framework. This fact suggests that it would be inadvisable for the current study to validate the JD-R model using qualitative data.

4.2. Research Instruments for Data Collection

Self-report questionnaire surveys were utilised as the primary research instrument for data collection. Their use is appropriate because the work psychology and occupational stress literatures indicate that almost all of the approaches to measuring wellbeing adopted by earlier studies involve the application of self-completion questionnaires. This measurement approach is endorsed by Robertson and Cooper (2011), who argue that the self-report questionnaire is the most widely used and successful method for gathering reliable information about psychological wellbeing, especially in organisations employing large numbers of workers. The reason for this is that the biological reaction to pressure and stress relies on the individual employee's subjective experience (Robertson & Cooper, 2011). On the strength of this logic, it can be deduced that employees' subjective evaluation of their own psychological wellbeing, based on psychometrically sound self-completion questionnaires, is likely to yield the most informative data.

In addition, following Boxall, Guthrie and Paauwe's (2016) advice, twenty-one semi-structured interviews with key informants (nine line managers, ten front-line workers and two HR professionals) were conducted prior to the administration of the questionnaire surveys in order to understand the specific research context. Collecting qualitative data as supplementary information is important because, for a questionnaire to be effective, it has to include the salient concerns raised by workers and ask good questions in the right manner (Gable, 1994; Robertson & Cooper, 2011). This can only be achieved by interviewing key informants before the survey administration, as a result of which the most relevant and predominant issues perceived by employees in the case organisation can be identified, and used as guidance for the design of the follow-up questionnaire survey. Conducting preliminary interviews also assists the researcher to create a general picture of the organisational structure and culture, thereby gaining a better understanding of the research context (Aaltio & Heilmann, 2010). Moreover, the information derived from these interviews is conducive to the clarification and specification of the data sources required for the current study (Aaltio & Heilmann, 2010).

4.3. Research Company and Survey Participants

The current study took place in a Chinese transportation-equipment manufacturer employing about 700 employees (within which approximately 500 are front-line operatives doing shift work). The case company is specialised in the production of dry cargo container, refrigerated container, natural gas storage equipment and chemical material transportation equipment. It contains three primary production plants including welding, paint and assembly. Front-line workers in the company are organised into work teams which are the basic unit in performing daily production tasks on the shop floor. Each work team shoulders direct responsibilities for product quality, cost control and machinery maintenance for its assigned work block. All of the members within a team share responsibilities for work undertaken by the team and for participation in continuous improvement programs.

Prior to the implementation of lean manufacturing, the company employed the mass production system, which emphasized economies of scale, volume production and work standardisation. In keeping with the international industrial standards, the company first introduced the lean production philosophy in 2008 in order to reduce production waste, improve process efficiency and satisfy increased customer demands for product variety, manufacturing flexibility and smaller production orders. So far, there are six well-established lean practices that are being extensively applied on the plant floor, including '5S' (five terms beginning with 'S' utilised to create a workplace suited for visual control and lean production; Womack & Jones, 1996), TQM, JIT inventory control, TPM, continuous improvement programs and work standardisation.

This company was chosen as the research sample for two reasons. One is that the level of maturity of lean implementation is high in the current case company. This is evidenced by the fact that a number of lean practices have been fully implemented in all of the production plants. The other reason is that the company can provide a large sample of research participants given that it employs a total of 700 staff. This is particularly important for survey-based studies. From the measurement perspective, Kline (2011) argues that the application of structural equation modelling (hereafter SEM) techniques requires a large sample size of more than 200 valid cases. Considering this guiding principle and the common response rates to questionnaire surveys as reported in the literature, I decided to survey the entire population of front-line workers and line managers in the current company. In doing so, the possibility of meeting the minimum accepted standard of sample size in SEM analysis is likely to be increased.

4.4. Data Collection Procedures

The research data were gathered in two stages. Stage one involved multiple site visits and interviews with key informants. Stage two included the administration of two sets of questionnaire surveys targeted at front-line workers and line managers respectively. Visiting the company first prior to data collection is important because factory tours provide deeper insight into the real work situation on the shop floor and help researchers judge the truthfulness of participant responses to the survey (Longoni et al., 2013). The objective of site visits was two-fold. One was to investigate the history of lean implementation in the company and ascertain the degree of leanness, the other was to conduct exploratory semi-structured interviews with key organisational informants including front-line workers, line managers and HR professionals. Each interview session lasted about forty minutes. The worker interviews revolved around four topics, including employee perceptions of the work environment and job characteristics under lean production; perceived implications of lean production for their wellbeing; employee perceptions of changes in their jobs before and after lean implementation; and the lean practices they are currently using on the shop floor and how they are implemented. Conducting these interviews enabled me to identify the company-specific job demands and job resources that are most relevant to the workers under investigation. Similar interview questions were asked of line managers. In contrast, a different set of questions was used when interviewing HR professionals (e.g. what role do they play to support front-line workers adapting to the lean environment?).

The second stage of data collection involved the administration of two different sets of questionnaire surveys targeted at front-line workers and line managers respectively. Surveying both of the occupational groups was necessary because the preliminary interview results suggested that the job responsibilities and attitudes towards lean production differed between managerial staff and front-line workers. The two surveys aimed to capture the nature of the unique job characteristics for each group, and were distributed using the same procedures. First, the general manager was approached and offered a participation information sheet detailing the research objectives and benefits for the company. Then he was invited to review the content of the questionnaires and take part in the study. Upon his agreement, a specific date was designated for the distribution of the questionnaires. Prior to the survey distribution, the entire workforce was introduced to the study by me so that employees would become familiar with the objective and procedures of the study. Strict confidentiality and anonymity were guaranteed and all of the participants received an assurance that the current surveys were going to be conducted by a doctoral student from the University of Auckland, independent of the company. Apart from the researcher, no one in the company would see individual participants' responses to the survey. On the basis of this understanding, self-report questionnaires were then distributed during work hours by two coordinators from the HR department and me to the entire personnel in the meeting room using the paper-and-pen method. All of the front-line workers and line managers were invited to participate and kindly asked to return the survey in one week's time. Upon completion, questionnaires were placed by participants in a sealed envelope and submitted to either one of the two coordinators, who then relayed the questionnaires to me.

4.5. Ethics

Prior to data collection, an ethics application was submitted to the University of Auckland Human Participants Ethics Committee (hereafter UAHPEC), and approval was granted. During the course of the study, all procedures and research data were dealt with in line with the UAHPEC's guiding principles. These principles dictated a research design where 1) participation had to be entirely voluntary and this implied that neither workers nor line managers could be compelled to take part in the current study; and 2) all data had to be treated in confidence, stored securely, and used only for the purposes of this study. For ethical reasons, both the general manager and the interviewees were asked to sign the consent form before their participation (see Appendices E and K).

4.6. Measures

This section elaborates on the measurement scales adopted in the front-line worker and line manager surveys. In general, all of the variables in both surveys can be grouped into three categories. The first category refers to the predictor variables including specific forms of job resource, job challenge and job hindrance. These job characteristic variables were identified from the interview results and therefore were considered the most relevant to the participants under investigation. The second category includes two outcome variables, reflecting employee wellbeing – work engagement and exhaustion. The third and last category of the variables relates to respondents' personal information in order to identify general demographic characteristics, including gender, age and organisational tenure. The specific measurement scales adopted to gauge each of the above-mentioned variables are detailed in the next section. It is worth mentioning at this juncture that to ensure the reliability and validity of the measuring instruments, all but one of the scales included in the current surveys were derived from existing studies published in high-quality peer-reviewed journals. In addition, another selection criterion was applied that the instrument must have a reliability coefficient (i.e. Cronbach's alpha) of .70 or above. This decision was made in line with the recommendations from the literature (see Cunningham, 2008; Kline, 2011; Wang & Wang, 2012).

4.6.1. Design of the Front-Line Worker Survey

4.6.1.1. Job Resources

Three lean-specific job resources were measured in the worker survey, including line manager support, lean production training and employee participation in decision-making. These resources were chosen because they emerged from interview results as the most frequently cited job characteristics that were conducive to improving employee occupational health and wellbeing.

According to the interviewed workers, line manager support was the most important resource they received in the lean production plant. This is best exemplified by one worker's comment:

> It is my line manager that I interact with the most frequently in the day-to-day operation. He decides my everyday tasks, offers on-the-job training and expertise useful for my work, and allocates the bonus among team members. In addition, he is always willing to help me when I need a special favour or when I have a difficult production problem to deal with.

In the case company, line managers are not only in charge of the operation of their work area but also responsible for providing technical expertise and training, planning work allocation, determining bonus distribution and evaluating workers' performance. All of these activities, if undertaken effectively by line managers, can serve as social support for workers to adapt to the lean work environment.

Besides line-manager support, interviewees also commented on the importance of the provision of extensive training in helping them to learn lean techniques and tools. Workers reported that lean production training provided them with the technical knowledge and skills necessary for performing their jobs effectively. For example, through training activities, they have learnt to use a variety of lean tools proficiently. The solutions to deal with common quality or technical problems were also taught during training sessions. As a result, recurring issues were minimized and the pressure on workers to resolve unexpected production problems was significantly reduced. A steadier production flow was established in their daily operations. These benefits of lean production training are likely to improve employee wellbeing.

In addition, interviewees reported that participation in decision-making was a common practice in their working life due to the implementation of continuous improvement initiatives and quality circle meetings. From the interviewees' perspective, having a high level of involvement in decision-making was beneficial to their wellbeing for two reasons. First, they felt that the company values their opinions. Second, increased participation in solving production problems and developing process-improvement strategies gave them opportunities for influence, learning and skill utilisation. Based on the above reasoning derived from the qualitative data, I took the view that these three job attributes widely experienced by the sample workers (i.e. line manager support, lean production training, and employee participation in decision-making) should be adopted as indicators of job resources in the present study. The specific scales for measuring each of the three constructs are introduced as follows.

Line manager support was measured using an adapted version of a six-item scale designed by Rhoades, Eisenberger and Armeli (2001). Example items are 'My manager really cares about my wellbeing' and 'My manager cares about my opinions'. The original scale consists of eight items in which six were positively worded and the other two were negatively worded. I modified this scale by removing the two negatively-phrased items. Making this decision is justified because previous studies have consistently found that negatively-phrased items often exhibit low factor loadings and cause problems for interpretation (see, for example, Piccolo & Colquitt, 2006; Schmitt & Stults, 1985). This is because, as argued by Baumeister, Bratslavsky, Finkenauer and Vohs (2001), positive and negative affective states may have different root causes. Namely, a high score on negative affect is not equal to a low score on positive affect and vice versa. Participants responded on a 7-point Likert scale ranging from '1 = strongly disagree' to '7 = strongly agree'. It should be noted that in the current study the response categories of both front-line worker and line manager surveys have been adapted to a seven-point Likert scales. This research decision is recommended by Lozano, Garcia-Cueto and Muniz (2008) who found that seven is the optimum number of response options in the Likert-type format to maximize scale reliability and validity. In line with this research finding, the decision was made in the present study that all of the measuring instruments in both surveys should be responded to using descriptors anchored by '1 = strongly disagree' and '7 = strongly agree'.

Lean production-related training was gauged using a three-item scale (Campion, Medsker & Higgs, 1993). Example items include 'The company provides me with adequate technical training in lean production' and 'The company provides me with adequate team skills training'.

Regarding the measuring instrument of employee participation in decision-making, no relevant existing scale could be identified in the literature that is adequate to capture the meaning of employee involvement in the lean production context. In light of this reality, the decision was made to construct a four-item instrument, drawing on the preliminary interview findings and exploratory field work. The four items are: 'I am encouraged to suggest ideas for improving standard operating procedures', 'My manager actively seeks my ideas for improving working conditions', 'My manager welcomes my ideas when I speak up in quality circle meetings' and 'My manager actively seeks my opinion when we encounter a production problem'. Using a second, independent sample of 238 workers employed by a different lean manufacturer producing stainless steel products (e.g. auto parts and valve parts), I submitted these four items to an exploratory factor analysis. Only one factor with eigenvalues above one emerged from the analysis, explaining 69.73 per cent of the total variance. This was also confirmed by the scree plot which showed an inflexion point that would justify retaining only one factor. The four items loaded highly on this single factor with factor loadings ranging from .786 to .874. These findings provided strong evidence for the reliability and validity of this self-constructed scale for measuring employee participation in decision-making under lean settings.

4.6.1.2. Job Challenges

Problem-solving demands was measured as the single indicator of job challenges in the worker survey. Making this decision was also informed by the preliminary interview findings. During the interviews, when being asked about their perceptions of job changes after lean implementation, participants consistently pointed to the increased level of problem-solving demands. As one worker put it:

> Participating and proposing solutions in quality-circle meetings is now compulsory for me and is a primary criterion for my performance evaluation under the lean scheme. Every month, my line manager asks me to submit a few suggestions for product innovation or process improvement as a result of the problem-solving exercise. Such activities, which were originally handled by my line manager and technicians, now impose a lot of extra workload on me.

The advent of increased problem-solving demands is attributed to the integration of different functional departments and the adoption of JIT inventory control in the company. The interviewees explained that, in order to facilitate collaboration among workers from different subunits, the company had removed barriers between different functions that previously allowed them to work in relative isolation. Under such circumstances, their problem-solving demands inevitably extend beyond their own functions to incorporate aspects of adjacent production stages.

Although the increase in problem-solving demands represented additional workload, most of the interviewees regarded them as incentives to make a more significant contribution to the company and to advance their own career. As one said:

> The problem-solving exercises enable me to have more frequent access to the plant manager. This is a good opportunity for me to show him my work capability. The more production problems I help my plant to resolve, the better impression I will leave on him. This will eventually help me with my promotion. A lot of my previous colleagues work their way up from the ranks via this avenue … In addition, my input in the quality-circle meetings is directly related to my pay. Therefore, I can earn more if I contribute more ideas.

Given that problem-solving demands was perceived by workers as both effort-consuming and motivational, I decided to measure it as an indicator of job challenges, using a five-item scale (Jackson, Wall, Martin & Davids, 1993). Example items include: ‘I am regularly required to deal with problems which are difficult to solve’ and ‘I regularly encounter problems in my job that I have not met before’.

4.6.1.3. Job Hindrances

Worker interviewees also commented on the detrimental effect of role overload, an obvious job hindrance leading to worsened wellbeing outcomes. According to them, there is a considerable discrepancy between the quantity of job tasks expected of them and the amount of time and resources they are given to complete the tasks. As one worker said:

> Since the introduction of lean … I have to work faster and harder to keep up with the production pace. What is worse, I also need to attend to a lot of other activities that I believe are irrelevant to production, such as equipment maintenance and 5S (housekeeping). The increase in workload makes me feel worn out after my shift.

These qualitative data enabled me to identify role overload as a hindrance demand in this context. This construct was gauged using a four-item scale that was adapted from Beehr, Walsh and Taber’s (1976) scale. The original scale contained six items but I deleted the two positively-worded items according to Piccolo and Colquitt’s (2006) advice. Example items include: ‘I never seem to have enough time to get everything done’ and ‘It often seems like I have too much work for one person to do’.

4.6.1.4. Task Interdependence

According to the interview findings, task interdependence was also a common job characteristic for front-line operatives. Interview participants explained that their high level of task interdependence was attributed to the functional integration across departments and the removal of buffer inventory between production processes. These lean practices made their work activities more closely coordinated and interrelated. In view of these facts, task interdependence was also included in the worker survey as a prominent job feature that is characteristic of the current lean case company. The purpose of including this construct is to test whether it can predict employee wellbeing and what role it plays in the JD-R model. Task interdependence was measured with Pearce and Gregersen's (1991) five-item scale. Example items are: 'I work closely with others in doing my work' and 'I frequently must coordinate my efforts with others'.

4.6.1.5. Employee Wellbeing

Being the core components of work engagement as suggested in the literature (e.g. Demerouti, Mostert & Bakker, 2010; Langelaan et al., 2006; Llorens et al., 2007; Salanova & Schaufeli, 2008), both vigour and dedication subscales were adopted to measure work engagement. Each of the subscales comprises three item responses and was derived from the shortened version of the Utrecht Work Engagement Scale (Schaufeli, Bakker & Salanova, 2006). Example items are: 'When I get up in the morning, I feel like going to work' (in the vigour subscale) and 'My job inspires me' (in the dedication subscale). Participants answered on a 7-point response format from '1 = never' to '7 = always (everyday)'.

The exhaustion scale from the Oldenburg Burnout Inventory (OLBI; Demerouti, Bakker, Vardakou & Kantas, 2003) was employed to measure exhaustion in the current study. The scale was originally developed using Western samples and included eight items, four being positively-worded and the other four negatively-worded. By surveying 700 Chinese nurses, Hu and Schaufeli (2011) found a different factorial structure of the scale in China, where only the four negatively-worded items were retained. They found that the 'positively-phrased items constitute a separate factor that is considered to be an artefact' (p. 107). In line with Hu and Schaufeli (2011), I decided to adopt the same four items to gauge exhaustion in the current Chinese research settings. Sample items are: 'There are days when I feel tired before I arrive at work' and 'After work I usually feel worn out and weary'.

4.6.1.6. Demographic Information

Four questions were developed to elicit respondents' background information in order to capture general demographic characteristics. These questions included gender, age, organisational tenure, and the highest education level. These questions were chosen because they are the most common demographic variables used in previous studies (see, for example, Bakker, Hakanen, Demerouti & Xanthopoulou, 2007; Cullinane et al., 2013; Demerouti et al., 2001; Schaufeli & Bakker, 2004).

4.6.2. Design of the Line Manager Survey

The necessity of investigating line managers' perceptions of the impact of lean implementation on their wellbeing emerged from both the interviews prior to survey administration and the review of academic literature. The qualitative data from the interviews consistently showed that line managers experience lean production differently from front-line workers. For example, when being asked about what they perceive is the most salient negative job change since lean application, the majority of line managers reported increased levels of role overload. This is so because they now have to assume more responsibilities and multiple tasks simultaneously, which were originally undertaken by technicians, such as equipment maintenance and the design of standard operating procedures. As one line manager commented:

> Under the lean scheme, we as front-line supervisors are asked by the plant manager to design the standard operating procedures and then train our subordinates to implement these procedures consistently. I know this practice will be useful for improving productivity eventually, but it is costing me a lot of time, which should have been spent on direct production activities. In addition, lean production brought about shortened cycle time and increased workload. As a result, I have to work harder or even work overtime to get my job done.

In terms of the prevalent job challenges faced by line managers, results from the interviews pointed directly to job complexity and problem-solving demands. For example, a number of interviewees raised the issue that, after the introduction of TPM programs, they had to shoulder new assignments such as machine maintenance and fault detection. Also, technical training, holding quality-circle meetings and coaching workers to use various lean tools all became part of line managers' job responsibilities. The addition of these tasks made their jobs more complex because the new challenges often force line managers to learn new technical and analytical skills, such as computer and diagnostic skills. An increase in problem-solving demands is another salient job challenge in the current case company as perceived by line managers. One interviewee reported that 'under the JIT work environment, I have to develop and keep up-to-date a mental image of the entire production process in order to anticipate problems and to deal with them when they occur'. According to the interviewed line managers, the delayering of the middle management team is another cause of their heightened problem-solving demands. They reasoned that when problems arise in the production process they are now solely responsible for immediately reacting to those problems.

Regarding the job resources most relevant to the line manager group in the case company, training, top management support, work method autonomy, and decision-making autonomy emerged from the interviews. As with workers, line manager interviewees also emphasized the importance of training associated with lean techniques such as '5S' and the 'kanban' system (a small card attached to boxes of parts that regulates 'pull' in the production system by signalling upstream production and delivery; Womack & Jones, 1996). Line managers suggested that training activities had equipped them with learning opportunities and broadened their skill variety, thereby facilitating their work accomplishment.

Top management support is another prevailing job resource widely experienced by interviewed line managers. According to the qualitative data, participants described their senior managers as role models of the company's lean philosophy who understand the daily work and live the lean principles. For example, it was reported that senior management is in charge of initiating and preserving lean production goals and culture. Moreover, the top leadership team actively adjusts performance appraisal and remuneration systems to encourage employee involvement in lean production. All of these facts indicated that top management support is an important job resource for line managers and thus was included in the current survey.

Work method autonomy and decision-making autonomy were perceived by line managers to be enhanced. The increase in work method autonomy is conceivable because line managers are now the primary designer of standardised operating procedures, who determine which particular work method to use. In addition, the managerial interviewees reported that as a result of lean implementation, their team-level decision-making autonomy was strengthened. As the leader in the work group, line managers are delegated with the power to exercise the team-level decision-making autonomy. This was exemplified by the fact that line managers in the case company can determine the majority of shop-floor activities, such as the allocation and pace-setting of work, production scheduling and flexible working hours. As one reported: 'for each work team, we are given a small fund by the plant manager as a high temperature subsidy and meal allowance.

I get to decide how to distribute the money among my team members'. These qualitative data suggest that work-method autonomy and decision-making autonomy are also two salient job resources for the line manager group.

Task interdependence also emerged from the interviews as a salient job characteristic for line managers in the case company. This is reflected in one interviewee's comment: 'our work sequence is predetermined. Therefore, the way I perform my own tasks has to rely on the tasks undertaken by my colleagues in other workstations'. To explain the high level of task interdependence, interviewees reported that this has to do with the lean production objective of continuous production flow. In an effort to achieve this goal, the company encourages inter-departmental exchanges and develops cross-functional interdependence. As a result, task interdependence becomes a fundamental element of work for both managerial and non-managerial employees. This finding led to the inclusion of task interdependence as a lean-specific job characteristic in the current manager survey.

For the shared theoretical constructs that are applicable to both managers and workers, the same measurement scales continued to be used in the line manager survey. These include the work engagement scale, the exhaustion scale, the role overload scale, the problem-solving demands scale, the task interdependence scale and the training scale. In addition, four additional scales measuring top management support, job complexity, work method autonomy and decision-making autonomy respectively were included in the manager survey, representing unique job characteristics for the manager group.

Top management support was measured using a seven-item scale (Ugboro & Obeng, 2000). Sample items include: 'Top management has devised credible reward systems that recognise employees and managers for their lean production achievements' and 'Top management's vision and commitment to lean production is continually communicated to all employees'. All responses were made on a seven-point Likert scale anchored by '1 = strongly disagree' and '7 = strongly agree'. Job complexity was measured on a four-item scale (Morgeson & Humphrey, 2006). Example questions are: 'The job requires that I only do one task or activity at a time' and 'The tasks on the job are simple and uncomplicated'. The response format was also a seven-point Likert scale ranging from '1 = strongly disagree' and '7 = strongly agree'. Because all of the four items were negatively phrased, they were reverse coded prior to data analysis so that a high score on the scale indicated a high level of job complexity. Work method autonomy was measured with a three-item scale by Morgeson and Humphrey (2006). Sample questions are: 'The job allows me to make decisions about what methods I use to complete my work' and 'The job allows me to decide on my own how to go about doing my work'. To measure line managers' decision-making autonomy, Morgeson and Humphrey's (2006) three-item scale was used. Example questions are: 'The job gives me a chance to use my personal initiative or judgement in carrying out work' and 'The job allows me to make a lot of decisions on my own'. Participants responded to a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree).

As with the worker survey design, the same four questions were used in the line manager survey to record respondents' background information. These questions included gender, age, job tenure, and the highest level of education.

4.7. Survey Translation

Prior to survey distribution, both the line manager and front-line worker questionnaires were translated into Chinese and back translated into English to maintain semantic equivalence (defined as the equivalence in the meaning of words and sentences; Guillemin, Bombardier & Beaton, 1993) between language versions. The back translation method was adopted because it facilitates the improvement of translation accuracy and the achievement of conceptual equivalence of corresponding questions written in two different languages (Van de Vijver & Leung, 1997). Because of this virtue, back translation has become the most widely practiced technique in the literature for cross-national questionnaire translation (see for example, Brough, Timms, Siu, Kalliath, O'Driscoll & Sit, 2013; Hu, Schaufeli & Taris, 2011, 2013).

There were four phases involved in the process of survey translation. First, the original versions of the two surveys in the English language were translated into Chinese. This task was completed by two bilingual translators – an English-language teacher from China and me. Every translator worked independently and no discussion or communication was made between them. This process produced two Chinese versions of both worker and line manager surveys. In the second phase, the two Chinese-translated versions of both surveys were compared with each other to evaluate the congruency of the translation and identify discrepancies between them. When inconsistent items were pinpointed, consultation was made with a bilingual university lecturer specialising in human resource management. The purpose was to seek expert advice on the accuracy of the translation and whether the Chinese versions of the two surveys were written in common and non-technical language. By means of consultation with the bilingual lecturer, all of the incongruent items were revised and consistency was eventually achieved. Subsequently a single draft of both Chinese-translated worker and line manager surveys was produced and sent to a professional Chinese/English translator in the third phase. The professional translator who had not seen the original English surveys was kindly required to translate the two Chinese surveys back into English. Working with this particular translator was a well-thought-out decision. As suggested by Behling and Law (2000), back-translators should possess no prior knowledge on the topic area and be unaware of the content of the original questionnaire in the source language so that translation biases and expectations can be minimized. After the English back-translated version of both surveys was returned, the fourth phase took place to compare the original English version with the back translated version. The objective of this comparison was to identify translation problems and test for semantic equivalence. This task was undertaken by two evaluators – the bilingual university lecturer in human resource management and me. If the questionnaire items between the two English versions were considered identical or comparable in language, the two evaluators assumed that the semantic equivalence between corresponding questions written in two different languages was maintained. Under such circumstances, the Chinese translated surveys were regarded as an adequate translation of the original English versions. In contrast, when inconsistent items between the two English versions were identified such as different choices of wording and grammar, the professional translator of the English back-translated surveys was contacted to clarify the discrepancies and reach a mutually agreed-upon solution for revision. Based on the lessons learnt from this back-translation process, the Chinese translated versions of the two surveys were revisited to further correct for translation errors. Also, the language and sentence structures were modified to achieve a higher level of conceptual equivalence between the original and Chinese-translated surveys. After going through all of these four phases, the Chinese versions of both line manager and worker surveys were finalised. The next section depicts the pilot study conducted in the case company using these two Chinese translated surveys.

4.8. Pilot Study

A pilot study was conducted to test if the Chinese-translated surveys could be correctly understood by the target participants. Eight front-line workers and seven line managers participated in the study. During their work time, participants were invited to gather in the meeting room and kindly asked to fill out the surveys in my presence. This arrangement was made deliberately in order to estimate the time participants needed to complete the surveys. It was revealed that line managers on average took eighteen minutes to fill out all of the questions whereas front-line worker surveys required slightly more time to complete the survey (twenty to twenty five minutes). After survey submission, participants were also invited to comment on the comprehensibility and readability of the questionnaire items and make suggestions for further improvement. This practice aimed to identify and correct any infrequently used Chinese expressions and unclear wordings, thereby improving the user-friendliness of the two surveys.

Emerging from the pilot study, the predominant comment about the survey design given by the participants related to the lengthiness of the questionnaires. Bearing this comment in mind, I still decided to retain all of the questionnaire items. The reason for this is that each of them measures different and indispensable facets of the underlying theoretical constructs that are of interest in the current study. In addition, no comments regarding ambiguous wordings or difficulties in comprehension were raised by the participants. Therefore, no further revisions of the surveys were needed. To sum up, the feedback obtained from the pilot study confirmed that the survey administration process worked very well and every item in the questionnaires was readily comprehensible for the participants. For the survey data gathered in the pilot study, they were kept and combined into the final data set for analysis because the data collection process did not change.

To resolve the problem about the lengthiness of the survey as proposed by participants in the pilot study, I plan to separate the measurement of predictors and outcome variables in two different surveys in future studies. In doing so, not only can the time participants spend on completing the survey be significantly reduced, but also the potential for common method bias can be reduced. However, it should be noted that this survey distribution strategy is possible only for surveys of a non-anonymous nature.

4.9. Data Analysis Techniques for the Worker Data

Structural equation modelling (hereafter SEM) analysis was adopted in the current study as the primary data analysis technique. SEM is an umbrella term that includes a number of statistical methods such as multiple regression, path analysis, confirmatory factor analysis (hereafter CFA), and univariate and multivariate analysis of variance (Cunningham, 2008). This technique was chosen for two primary reasons. First, it enables researchers to account for the measurement error that is inherent in the measures used to operationalise their theoretical constructs. By using SEM, measurement error is estimated and thus partitioned out, whereby the true relationship between the variables of interest can be identified (Kline, 2011). The second reason why SEM is the most suitable technique for data analysis here is that it can easily perform moderation-effect tests involving latent variables, which constitute the core of the current study. The Mplus (version 7.4; Muthen & Muthen, 1998-2015) computer software package was chosen for estimating structural equation models. To my knowledge, Mplus is the only software to date that supports the bootstrapping function with latent interaction terms. This functionality is essential for testing moderation effects in the current study. In addition, the Statistical Package for Social Science (hereafter SPSS) software package (version 22) was applied in the study for initial data screening.

4.10. Data Analysis Procedures for the Worker data

This section elaborates on each of the five stages taken in the course of data analysis as suggested by Kline (2011). These five stages are 1) data screening; 2) missing value analysis; 3) statistical assumption testing; 4) testing factorial validity of the measurement model; 5) structural model estimation. In the first stage, the raw data set was screened in search of potential data problems including data entry errors, out-of-range values and outliers. Frequency tables and descriptive statistics were produced to identify data entry errors and out-of-range values. Univariate outliers were recognised by checking box-plots and histograms with normal distribution overlays. The second stage mainly dealt with missing values. The missing value analysis was conducted in SPSS to ascertain the amount and location of missing observations, which subsequently determined how to cope with the missing cases.

Stage three examined whether the current data meet three statistical assumptions held by the SEM analysis. These assumptions are bivariate linearity (i.e. the relationship being modelled should be a linear one), homoscedasticity (i.e. the residuals at any given level of the predictor variables should have equal variance), and univariate and multivariate normal distribution of the data (Kline, 2011). Multivariate normality is the assumption that 'each variable and all linear combinations of the variables are normally distributed and independent' (Tabachnick & Fidell, 2014, p. 112). Meeting these assumptions is important in order to produce unbiased parameter estimates (Kline, 2011). In line with Tabachnick and Fidell (2014), a series of bivariate scatterplots was visually examined in search for evidence of linearity and homoscedasticity of pairs of variables. Box-plot, histograms with normal distribution overlays, and skewness and kurtosis indices were generated to ascertain the extent to which each of the variables deviates from a univariate normal distribution. According to West, Finch and Curran (1995), values of skewness and kurtosis exceeding two and seven respectively indicate a moderately non-normal distribution of the data. Departures from multivariate normality were investigated by conducting Mardia's multivariate kurtosis test (Mardia, 1974) and a significant p-value at the 0.1% level indicates violation of the multivariate normality assumption (Wang & Wang, 2012). If this happens, the estimation method of a Satorra-Bentler (SB) chi-square test (i.e. MLM estimator in Mplus) will be used for data analysis to deal with non-normality (Satorra & Bentler, 1988). This method is a maximum likelihood estimator that functions as a correction for the chi-square statistic and is robust under non-normality (Wang & Wang, 2012). In view of this virtue, the SB chi-square test is widely accepted in the literature as one of the best alternative test statistics for assessing model fit when the assumption of normality is violated (Hu, Bentler & Kano, 1992; Chou, Bentler & Satorra, 1991; Wang & Wang, 2012).

The fourth stage in data analysis determined the factorial structure of the measurement models through confirmatory factor analysis (CFA) and then cross-validated the full measurement model using a second data sample (N = 238) collected from a different lean manufacturer. This procedure is important for two reasons. First, if the measurement model indicates a poor fit to the data, then further investigation of the structural model will be inaccurate and biased (Kaplan, 2000). Second, the current surveys are made up of translated measurement scales, most of which have never been applied in China before. Therefore, Beaton, Bombardier, Guillemin and Ferraz (2000) suggest that it is necessary to first establish the factorial validity of the translated version of scales in a new research setting before any structural equation models are tested. There are two statistical tests applied at this stage. One test is to conduct CFA on a series of one-factor congeneric measurement models that measure each of the study variables. The one-factor congeneric model is 'the simplest form of measurement model and represents the regression of a set of observed variables on a single latent variable' (Cunningham, 2008, p. 75). The purpose of this test was to ensure that all of the items within a scale hypothetically reflecting the same underlying construct (i.e. a latent variable) are unidimensional. Checking for unidimensionality is significant because it confirms that the items theoretically supposed to reflect a latent construct indeed measure the construct in reality (Joreskog & Sorbom, 1996). In addition, unidimensionality signals convergent validity of the measuring scales (Cunningham, 2008). If the data do not fit the model, further model modification is required by dropping the inconsistent items according to two criteria: 1) the item shows a high cross-factor correlated measurement error and 2) the standardized factor loading of the item is either below .40 or non-significant (Cunningham, 2008). After these one-factor congeneric models have been revised and demonstrated good fit to the data, the second test will be performed of cross-validating the full multi-factor measurement model comprising all of the variables using a second, independent sample.

If the full multi-factor measurement model fits the validation data adequately, the analysis proceeds to the final stage where the structural models specifying direct relationships between predictors and outcome variables are tested. The focus here is to estimate the magnitude and significance of path coefficients provided that the structural models demonstrate a good fit to the data in the first place.

4.11. Judging Criteria for Model Fit

In line with the literature, I adopted the three most commonly reported goodness-of-fit indices to evaluate data-model fit. These indices together with their respective minimum accepted standards of model fit are the Standardised Root Mean Square Residual (SRMR ≤ .08; Hu & Bentler; 1999), the Root-Mean-Square Error of Approximation (RMSEA ≤ .08; Browne & Cudeck, 1993; McDonald & Ho, 2002), and the Comparative Fit Index (CFI ≥ .90; Bagozzi & Edwards, 1998; Wang & Wang, 2012).

It is acknowledged that reporting the chi-square statistic is a standard practice in the literature. The chi-square statistic investigates whether the model-implied variance-covariance matrix is significantly different from the variance-covariance matrix implied by the sample data. If the p-value is above .05 then it is safe to conclude that the hypothesized model is a good fit to the data (Kline, 2011). However, the chi-square statistic is sensitive to sample size. The larger the sample size, the more likely the p-value associated with the chi-square will be below .05, erroneously rejecting the hypothesized model (Cunningham, 2008, Geiser, 2012; Kline, 2011; Wang & Wang, 2012). Considering this limitation of the chi-square statistic and the big sample size of the current study (N = 371), the decision was made that the chi-square statistic would not be used here as a criterion to judge model fit. This is a standard practice in the literature applying SEM techniques (e.g. Bakker, Demerouti & Schaufeli, 2003; Hu, Schaufeli & Taris, 2013; Hu et al. 2011). Having said that, the chi-square statistic would still be reported in the current study as a research convention.

4.12. Data Analysis Techniques for the Line Manager Data

For the line manager data, path analysis in Mplus was applied for data analysis instead of SEM, which requires a minimum sample size of 200 observations. As a specific application of multivariate regression, path analysis is a technique for offering explanations of causal relationships among a set of observed variables. The advantage of path analysis over conventional multiple regression is that it enables the simultaneous estimation of multiple outcome variables in one path model (Geiser, 2012). Adopting this technique is necessary due to the small sample size of the line-manager data (N = 94) and the multiplicity of outcome variables under investigation. Also, SPSS (version 22) was utilized for initial data screening.

4.13. Data Analysis Procedures for the Line Manager Data

There are four steps in the process of analysing the line manager data. These are 1) data screening; 2) missing value analysis; 3) statistical assumption testing; and 4) path model analysis. In the first step, the raw data set was screened in search of potential data problems including data entry errors, out-of-range values and outliers. Frequency tables and descriptive statistics were produced to identify data entry errors and out-of-range values. Univariate outliers were located by examining histograms and box-plots. When inspecting histograms, an outlier is a case that appears to be unattached to the rest of the distribution. On the box plots, cases that fall far away from the box are extreme. The second step mainly dealt with missing values. The missing value analysis was conducted in SPSS to identify the amount and location of missing observations, which in turn determined how to deal with the missing observations.

Step three examined whether the current data meet four statistical assumptions underlying multiple regression analysis. These assumptions include: 1) no perfect multicollinearity, 2) homoscedasticity, 3) linearity, and 4) normal distribution of residuals (the differences between the model-implied and observed outcome variable values) (Tabackhnick & Fidell, 2014). No perfect multicollinearity means that predictor variables should not correlate too highly with each other (i.e. Pearson correlation > .90). Homoscedasticity implies that the variability in scores for one continuous variable is roughly the same at all values of another continuous variable. The assumption of linearity requires that there is a straight-line relationship between the predictor and the outcome (Tabachnick & Fidell, 2014). Whether these two assumptions were met was determined by inspecting a series of bivariate scatter-plots of pairs of the study variables. If the scatterplots were oval-shaped and of approximately the same width all over with some bulging towards the middle, this pattern provides evidence for the tenability of homoscedasticity and linearity (Tabachnick & Fidell, 2014). Last but not least, the assumption of normality of residuals requires that the residuals in the model should be random, normally-distributed variables with a mean value of zero. To test this assumption, both histograms and expected normal probability plots of the standardized residuals were inspected. The following patterns are indicative of a situation where the assumption of residual normality has been met: the distribution of residuals on the histogram is symmetrical and the observed residual points in the probability plot all lie closely to the ideal diagonal line.

The fourth and last step was to test and evaluate the postulated path models in Mplus. The statistical significance of the estimated path coefficients determined the tenability of various research hypotheses.

4.14. Chapter Summary

The key points that have been covered in this chapter include the following. Adopting a quantitative research method, I surveyed 375 front-line workers and 94 line managers from a Chinese lean manufacturer to examine how various job characteristics (i.e. job resources, job challenges and job hindrances) affect employee wellbeing (i.e. exhaustion and engagement). Prior to survey data collection, multiple site visits and interviews with both managerial and non-managerial employees were conducted. The purpose was not only to better understand the organisational context, but also to guide the design of two sets of questionnaires for line managers and workers respectively. Informed by the interview findings, I included the company-specific indicators for job resources, challenges and hindrances in the surveys. To elaborate, in the questionnaire for workers, three job resources (training, line manager support and employee participation in decision-making), one job hindrance (role overload) and one job challenge (problem-solving demands) were measured as the independent variables predicting employee engagement and exhaustion. All of these indicators were also retained in the line manager survey. Apart from that, three job resources unique to the line manager group were included (top management support, work-method autonomy and decision-making autonomy) in the manager survey. The two surveys were back translated into the Chinese language and then piloted among a small sample of workers and line managers in the same case company to test the reader-friendliness of the questionnaire formats and the clarity of the question wording. Importantly, a second, independent sample (N = 238) was collected from a different lean company. It was used to cross-validate the full multi-factor measurement model derived from the primary data, thereby increasing the reliability and generalisability of the research findings. The SEM technique was adopted for analysing the worker data whereas the path analysis technique was utilized in the analysis of the line manager data due to the smallness of the sample size. The next two chapters will report the results of statistical analyses for the worker and the line manager data.

5. Chapter Five: Results from the Front-Line Worker Survey

This chapter reports the results from the worker survey regarding their work experiences in lean production. The chapter covers the following ten themes related to the present survey data: 1) the demographic information of the survey participants; 2) the results from data screening and missing value analysis; 3) testing the extent to which the survey data conform to the statistical assumptions underlying SEM; 4) examining the factor structure of each measurement scale used in the survey; 5) cross-validating the full multi-factor measurement model proposed in the study; 6) investigating convergent and discriminant validity of the postulated full measurement model including all variables; 7) diagnosing the severity of common method bias; 8) displaying the correlation matrix of the study variables; 9) findings from testing the hypotheses regarding the motivational and health-impairment processes as outlined in the JD-R model; and 10) results of testing the interaction hypotheses.

5.1. Demographic Characteristics of the Survey Respondents

The worker survey was distributed to the entire population of front-line operatives in the case company (N = 453) and 374 of the surveys were returned. However, in three of the surveys, the level of missing data was so great that they were considered unusable. This resulted in there being 371 usable surveys with a total response rate of 82 per cent. The survey respondents were primarily male (93 per cent). Considering the gender composition of the worker population that male workers take up 95 per cent of the entire personnel in the company, it is reasonable to believe that the current worker sample was representative because it was not considerably different from the total population in terms of gender. The mean age of the sampled workers was 30.93 years (SD = 7.94). Some 36.2 per cent of the participants were born in the 1990s and 41.2 per cent in the 1980s, 16.8 per cent in the 1970s and less than six per cent were born before the 1970s. The mean organisational tenure is 6.89 years (SD = 5.73): 60.8 per cent of the workers have been employed in the company for five years or less, 23.9 per cent have been there between six and ten years, and the rest (15.3 per cent of the workers) have been working there for more than ten years. In terms of academic qualifications, 29.9 per cent of the workers had only completed high school, 63.7 per cent had obtained a technical and vocational education, 3.2 per cent had a college education and the remaining 3.2 per cent had achieved a university degree.

5.2. Data Screening

Prior to primary data analysis, the raw data set was first screened in SPSS to identify data entry errors and the nature of the missing data. Frequency tables and descriptive statistics for each variable were produced to check for mistyping and out-of-range values. No such issues were identified. The nature of the missing data was investigated using the missing value analysis in SPSS. It was shown that the number of missing observations was so small among the substantive variables of interest: none of them had more than five per cent of data missing. This is a good indication because, according to Kline (2011), ‘a few missing values, such as less than five per cent on a single variable in a large sample may be of little concern’ (p. 55). Under such circumstances, Cunningham (2008) argues that no data imputation is needed. In accordance with this suggestion, I decided not to estimate missing values for the substantive variables of interest in the current study. Instead, the ‘available case method’ (Kline, 2011) which analyses only the available data via removal of incomplete observations was adopted to deal with missing observations.

In contrast, SPSS results of missing value analysis indicated that a large quantity of missing observations were concentrated in the three demographic variables (i.e. age, gender and organisational tenure) where one third of the subjects did not provide an answer for these variables. A likely explanation for this phenomenon is that the questions used to measure these variables were placed at the end of a six-page-long worker survey. The lengthiness of the worker survey may have caused participants to skip these questions due to their loss of patience. Given that the demographic variables are not critical to the hypothesized model as outlined in the current study, I decided to exclude these variables from further analysis of the structural models in order to avoid substantial loss of subjects. This research decision was suggested by Tabachnick and Fidell (2014).

5.3. Statistical Assumption Testing

According to Kline (2011), SEM analysis makes three primary assumptions regarding the distribution of the data. These assumptions include univariate and multivariate normal distribution of the data, bivariate linearity (i.e. the relationship being modelled should be a linear one), and homoscedasity (i.e. the residuals at any given level of the predictors should have equal variance). To test whether these assumptions are met, the following analyses were performed. First, box-plots, histograms with normal distribution overlays, and skewness and kurtosis indices were examined to ascertain potential univariate outliers and the extent to which scores of the questionnaire items deviate from a normal distribution. The results showed that all of the item scores in the survey have values of skewness and kurtosis less than one. This fact indicated an alignment with the univariate normality assumption, as suggested by West, Finch and Curran (1995). However, a few univariate outliers were located. After checking for accuracy, the decision was made to retain these outliers in the data set. This is because, given that the response format of the scale for each item included seven points, these identified outliers were extreme but legitimate scores. Departures from multivariate normality was ascertained using Mardia's multivariate kurtosis test. According to Wang and Wang (2012), this test producing a significant p-value at the 0.1% level indicates a deviation from multivariate normality. The results showed that a number of variables were not multivariate normally distributed. In view of this reality, the decision was made to adopt the estimation method of Satorra-Bentler (SB) chi-square test (i.e. MLM estimator in Mplus) in SEM to deal with the non-normality issue (Satorra & Bentler, 1988). In addition, an inspection of a series of bivariate scatter-plots was made to seek for evidence of bivariate linearity and homoscedasticity of every possible pair of the observed variables. No curvilinearity relationships and heteroscedasticity were found.

5.4. Determining Factor Structures of the Measuring Scales

Given that most of the Chinese-translated measurement scales used in the current study were applied in China for the first time, I decided to test the factorial validity of these scales. This procedure is important because it not only strengthens the reliability and generalisability of the research findings, but also adds to the Chinese lean production literature by offering valid Chinese-translated scales for measuring lean-specific job characteristics. To examine factorial validity of the measurement scales, I adopted Joreskog's (1993) strategy, which recommends a model-generating stage prior to a model validation stage. In the first stage, I specified the full multi-factor measurement model as postulated in the study. Then, rather than testing the full model, a series of one-factor congeneric measurement models for each variable was tested and assessed separately using the current worker data (i.e. the primary sample), before being tested in combination with all of the other variables. In each step of the one-factor measurement model testing, if the chi-square statistic did not meet the minimum accepted standards, changes were made to the model by dropping problematic items, one at a time, providing that the changes made substantive sense. Following Cunningham's (2008) advice, two types of items were removed, one type having a low standardized factor loading (< .40) and the other showing a high cross-factor correlated measurement error. In the second stage, after every variable had been evaluated singly, the full multi-factor measurement model including all of the variables was fitted to both the current worker sample and a second independent sample (i.e. the validation sample). If this full model derived from the model-generating process fits both data samples adequately, it can be concluded that the factorial validity of each of the measurement scales is tenable. The CFA results in the model-generating stage were reported as follows.

A series of one-factor congeneric models was estimated separately using CFA to determine the factor structure and uni-dimensionality of each measurement scale used in the study. The CFA yielded mixed results. Some of the scales turned out to be unidimensional, including work engagement (comprising vigour and dedication subscales), exhaustion, role overload, employee participation in decision-making and training (this construct was measured with only three items and thus was tested in pairs with the task interdependence scale for the purpose of model identification). The implication is that factorial validity of these scales is maintained when applied in a new population of Chinese workers. In contrast, the other scales displayed multi-dimensional properties and thus required further modification by dropping the inconsistent items. These scales comprise line manager support, task interdependence, and problem-solving demands. The results of model re-specification for each of these multi-dimensional scales are presented as follows. An important point to note at this juncture is that scale modification in cross-cultural research is common in the literature (see for example, Albrecht & Su, 2012; Demerouti, Le Blanc, Bakker, Schaufeli & Hox, 2009; Hu & Schaufeli, 2011; Jaramillo, Mulki & Boles, 2013). According to Beaton, Bombardier, Guillemin and Ferraz (2000), cultural differences explain why it is necessary to replace items or scaling so as to make measurement scales originally developed in English-speaking countries relevant and valid in a different culture. However, it should be noted that removing certain items from the original scale may impair the completeness of the domain coverage of the scale. There is a trade-off between achieving an acceptable level of statistical model fit and keeping the integrity of the domain coverage of the original scale. Because of the great importance researchers attach to the statistical model fit (e.g. Kline, 2011), I decided to prioritize the former goal. Having said that, this is not to suggest that the issue about the completeness of the domain coverage of the original scale is ignored in the current study. Instead, a cross-validation test was conducted to ensure that the domain coverage of the modified scales is still adequate when being applied in the Chinese context.

A one-factor congeneric model of the six items from the line manager support scale initially indicated a poor fit to the data: $\chi^2(9) = 40.606$, $p < .001$, CFI = .969, RMSEA = .097 and SRMR

= .029. After reviewing modification indices, one item was removed because it showed a high cross-factor correlated measurement error (see Appendix B for the dropped item). The remaining five items demonstrated unidimensional properties as evidenced by the adequate goodness-of-fit indices: $\chi^2(5) = 8.365$, $p = .137$, CFI = .995, RMSEA = .043 and SRMR = .017.

The original task interdependence scale with five items was also a poor fit to the data: $\chi^2(5) = 51.90$, $p < .001$, CFI = .91, RMSEA = .159 and SRMR = .072. An examination of the modification indices indicates that Item 4 had a high cross-factor correlated measurement error term. This fact led to the removal of this item and the model fit of the resulting model was improved but still below the minimum accepted standards ($\chi^2(2) = 12.039$, $p = .002$, CFI = .975, RMSEA = .116 and SRMR = .044). When revisiting the modification indices of this revised model, a new problem emerged that Item 3 showed a high cross-factor correlated measurement error. This observation led to the further removal of Item 3 (see Appendix B for the dropped items). Given that only three items remained in the task interdependence scale, this revised measurement model was tested in pairs with the training scale for the purpose of model identification. Finally, the two-factor measurement model containing the remaining three items from the task interdependence scale and the three items from the training scale turned out to be a good fit to the data, as evidenced by $\chi^2(8) = 8.821$, $p = .358$, CFI = .999, RMSEA = .017 and SRMR = .026.

The one-factor congeneric model of the problem-solving demands scale (5 items in total) originally yielded a poor model fit, as evidenced by $\chi^2(5) = 130.788$, $p < .001$, CFI = .710, RMSEA = .260 and SRMR = .108. An analysis of the CFA results led to the removal of Item 2 (see Appendix B). This is because it had a standardized factor loading lower than .40. After this revision, the re-specified model was found to adequately fit the data ($\chi^2(2) = 3.416$, $p = .181$, CFI = .995, RMSEA = .044 and SRMR = .021).

The final CFA results of testing the re-specified one-factor congeneric models are shown in Table 5.1. After modification, all of the one-factor models demonstrated good fit to the data and all of the individual items within each model had significant factor loadings above .40, which indicated good item reliability (Cunningham, 2008). These revised factorial structures of each variable will be used in further data analysis when testing the hypothesized structural models.

Table 5.1 The Revised Factorial Structure for Each Measurement Scale

Measurement scales	χ^2	df	p	CFI	RMSEA	SRMR
Work engagement (Vigour: Item 1, 2, 3 & Dedication: Item 1, 2 & 3)	4.610	8	.798	1.000	.000	.010
Training (Item 1, 2 & 3)	8.821	8	.358	.999	.017	.026
Employee participation (Item 1, 2, 3, & 4)	.038	2	.981	1.00	.000	.001
Exhaustion (Item 1, 2, 3 & 4)	2.490	2	.288	.998	.026	.015
Line manager support (Item 1, 3, 4, 5 & 6)	8.365	5	.137	.995	.043	.017
Task interdependence (Item 1, 2 & 5)	8.821	8	.358	.999	.017	.026
Role overload (Item 1, 2, 3 & 4)	4.885	2	.087	.990	.062	.020
Problem-solving demand (Item 1, 3, 4 & 5)	3.416	2	.181	.995	.044	.021

5.5. Cross-Validating the Full Multifactor Measurement Model

After the factorial validity of each measurement scale was determined, I combined them together to form a full multifactor measurement model, which was further cross-validated by fitting it to both the primary sample (i.e. the current worker sample) and the validation sample (N = 238) – an independent data sample collected from another lean manufacturer providing stainless steel products. The objective of cross-validation was to ensure that the full multifactor measurement model was not sample-specific, thereby increasing the reliability and generalisability of research findings (Cunningham, 2008). The CFA results showed that the full multifactor model under examination was a good fit to both data samples: In the primary sample, the model fit indices were adequate ($\chi^2(475)$ = 1144.250, CFI = .911, RMSEA = .062, and SRMR = .062). In the validation sample, the goodness-of-fit indices were equally acceptable ($\chi^2(475)$ = 772.741, CFI = .897, RMSEA = .054, and SRMR = .081). In addition, all of the items significantly loaded onto their intended factors in both samples (see Table 5.2). On the basis of these facts, it is safe to conclude that the full measurement model established in the current study is valid across different samples.

Table 5.2 The Standardized Factor Loadings of All Indicators in the Full Multifactor Measurement Model Estimated in Both the Primary Sample and the Validation Sample

Item	1	2	3	4	5	6	7	8	9
1. Employee participation_1	.752 (.669)								
1. Employee participation_2	.889 (.893)								
1. Employee participation_3	.829 (.766)								
1. Employee participation_4	.842 (.813)								
2. Training_1		.864 (.842)							
2. Training_2		.763 (.674)							
2. Training_3		.842 (.793)							
3. Line manager support_1			.806 (.725)						
3. Line manager support_3			.820 (.729)						
3. Line manager support_4			.897 (.707)						
3. Line manager support_5			.913 (.863)						
3. Line manager support_6			.667 (.591)						
4. Problem-solving demands_1				.371 (.525)					

4. Problem-solving demands_3				.768 (.603)					
4. Problem-solving demands_4				.876 (.621)					
4. Problem-solving demands_5				.375 (.552)					
5. Role overload_1					.573 (.681)				
5. Role overload_2					.470 (.618)				
5. Role overload_3					.777 (.630)				
5. Role overload_4					.793 (.741)				
6. Task interdepend_1						.840 (.717)			
6. Task Interdepend_2						.914 (.779)			
6. Task interdepend_5						.648 (.764)			
7. Vigor_1							.796 (.703)		
7. Vigor_2							.929 (.877)		
7. Vigor_3							.869 (.773)		
8. Dedication_1								.852 (.905)	
8. Dedication_2								.929 (.917)	
8. Dedication_3								.854 (.862)	
9. Exhaustion_1									.540 (.530)
9. Exhaustion_2									.792 (.699)
9. Exhaustion_3									.666 (.502)
9. Exhaustion_4									.688 (.755)

Note. Factor loadings for each measurement item. Upper rows give estimates from the primary sample, lower rows with bracket give estimates from the validation sample.

After determining and cross-validating the factor structure for each measurement scale, a logical next step was to specify how each of these scales was used in the structural model. There were six latent factors in the hypothesized structural model, including four predictors (i.e. job resources, job challenges, job hindrances and task interdependence), and two outcome variables (i.e. work engagement and exhaustion). The predictor job resources was measured as a second-order latent variable reflected by three first-order factors including training, line manager support, and employee participation. Likewise, work engagement was operationalised as a second-order latent variable, reflected by two first-order latent variables, vigour and dedication. The remaining four first-order latent variables, including job challenges, job hindrances, task interdependence and exhaustion, were all measured at the item level. This approach to measuring latent variables is widely used in the literature on the validation of the JD-R model (e.g. Akkermans, Schaufeli, Brenninkmeijer & Blonk, 2013; Bakker, Boyd, Dollard, Gillespie, Winefield & Stough, 2010; Bakker, Hakanen, Demerouti & Xanthopoulou, 2007).

5.6. Testing Convergent and Discriminant Validity

To examine convergent and discriminant validity, the full multi-factor CFA model was specified and tested using the primary sample. In line with Kline (2011), the following two criteria were applied in the evaluation: 1) all indicators specified to measure the same factor have medium to high standardized factor loadings on that factor; and 2) estimated correlations between any pair of the factors are not excessively high (< .90 in absolute value). The former result indicates convergent validity and the latter, discriminant validity.

A full measurement model including six latent factors (i.e. job resources, job challenges, job hindrances, task interdependence, exhaustion and work engagement) was tested using CFA in Mplus. The model was shown to be a good fit to the data ($\chi^2(475) = 1144.250$, RMSEA = .062, SRMR = .062, and CFI = .911). The CFA results clearly indicated the presence of convergent validity for the current model. This is evidenced by the fact that all indicators underlying a common factor had moderate to high standardized factor loadings to a statistically significant degree (see Table 5.3). These results suggest that all of the indicators are acceptable for reflecting their underlying factors. In addition, as displayed in Table 5.4, the estimated correlations between every possible pair of the six latent variables are all shown to be less than .85, providing evidence for the tenability of discriminant validity (Brown, 2006).

Table 5.3 Convergent Validity Evidence: The Standardized Factor Loadings of Items on Their Respective Factors

Item	1	2	3	4	5	6	7	8	9
1. Employee participation_1	.752								
1. Employee participation_2	.889								
1. Employee participation_3	.829								
1. Employee participation_4	.842								
2. Training_1		.864							
2. Training_2		.763							
2. Training_3		.842							
3. Line manager support_1			.806						
3. Line manager support_3			.820						
3. Line manager support_4			.897						
3. Line manager support_5			.913						
3. Line manager support_6			.667						
4. Problem-solving demands_1				.371					
4. Problem-solving demands_3				.768					
4. Problem-solving demands_4				.876					
4. Problem-solving demands_5				.375					
5. Role overload_1					.573				
5. Role overload_2					.470				
5. Role overload_3					.777				
5. Role overload_4					.793				
6. Task interdependence_1						.840			
6. Task interdependence_2						.914			
6. Task interdependence_5						.648			
7. Vigor_1							.796		
7. Vigor_2							.929		
7. Vigor_3							.869		
8. Dedication_1								.852	
8. Dedication_2								.929	
8. Dedication_3								.854	
9. Exhaustion_1									.540
9. Exhaustion_2									.792
9. Exhaustion_3									.666

9. Exhaustion_4	.688

To provide further support for discriminant validity, the bootstrapping technique in Mplus was utilised to produce 2,000 bootstrap samples when testing the full six-factor measurement model. Bootstrapping is a statistical method of resampling (Preacher & Hayes, 2008). Its objective is to most accurately estimate the standard error and confidence interval of a model parameter when the sample data are not normally distributed (Kline, 2011). The bias-corrected bootstrap confidence intervals (hereafter BCCIs) were used as the criterion to judge whether each of the pair-wise factor correlations can be equal to or higher than .90 – a value that is the cut-off of factor correlations for assuming discriminant validity (Kline, 2011). If the entire range of 95% BCCIs is below the value .90, the conclusion can be safely drawn that the estimated correlation between the two factors under investigation is not excessively high and thus discriminant validity is tenable. The CFA results of this test are shown in Table 5.4, which clearly indicates that the BCCIs for the estimated correlations of all possible pairs of factors are below .90. On this basis, it is reasonable to deduce the tenability of discriminant validity.

Table 5.4 Inter-Correlations among the Latent Factors with 95% Bias-Corrected Bootstrapped Confidence Intervals Estimated in the Full Measurement Model

	1	2	3	4	5
1. Job resources					
2. Job challenges	.577 [.421, .716]	.233 [.117, .341]			
3. Job hindrances	-.270 [-.424, -.096]	-.092 [-.264, .088]	.650 [.512, .764]		
4. Task interdependence	.539 [.410, .655]	.587 [.414, .704]	-.032 [-.166, .106]		
5. Exhaustion	-.122 [-.276, .038]	-.073 [-.216, .066]	.495 [.323, .639]	-.032 [-.165, .115]	
6. Work engagement	.643 [.533, .753]	.529 [.417, .640]	-.260 [-.409, -.092]	.330 [.164, .478]	-.432 [-.570, -.287]

Note. Upper rows give estimates of factor correlations, lower rows with bracket give estimates of 95% bias-corrected confidence intervals.

5.7. Testing the Effects of Common Method Variance

Given the use of self-report questionnaires in the current study, it is necessary to examine the extent to which the survey findings were influenced by common method bias. In line with Podsakoff, MacKenzie, Lee and Podsakoff (2003), this was accomplished by adding a latent common method factor to the present full measurement model proposed in the study. Each observed indicator in the model loads onto both their respective underlying factor and onto the common method factor. As the indicator of the common method effect, the significance and magnitude of the factor loading relating each observed indicator to its underlying factor is examined both with and without the latent common method factor in the model. In doing so, the portion of variance explained by the common method effect can be identified (Podsakoff, MacKenzie & Podsakoff, 2012). The CFA results showed that adding a common method factor regressed on all of the observed indicators did not considerably alter the significance and values of factor loadings, as compared to those produced in the original model excluding that common method factor. This was evidenced by the fact that changes in all of the factor loadings relating each observed indicator to its underlying factor were minimal (ranging from .002 to .18) after the inclusion of the latent common method factor. On the strength of these findings, it is reasonable to believe that the common method effect is unlikely to have biased estimates of construct reliability and validity, and the model-implied correlations between any two variables used in the current worker survey.

5.8. Descriptive Statistics

Table 5.5 displays the means, standard deviations, correlations and the reliability coefficients (i.e. Cronbach's alpha) of the variables used in the study. It is clear from Table 5.5 that all of the scales demonstrate good reliabilities (> .70). In addition, the bivariate correlations between variables are in the predicted directions. For example, the indicators of job resources (e.g. training and employee participation) are positively correlated with engagement and negatively correlated with exhaustion. Role overload as the proxy of hindrance demands is positively associated with exhaustion but negatively related to work engagement. All of these facts indicate that the postulated structural model established in the current study is likely to hold true. It is also worth recalling at this juncture that one third of values on the demographic variables (i.e. gender, age and organisational tenure) were missing. Given that they are not critical to the analysis of the hypothesized structural model, I adopted Tabachnick and Fidell's (2014) advice by excluding these variables from further analysis in order to avoid substantial loss of subjects. In addition, results from SEM analyses showed that even when these demographic variables were incorporated in the research model as predictors alongside job resources, challenges and hindrances, none of them was significantly predictive of any of the outcome variables (i.e. work engagement and exhaustion). Therefore, I believe that it is justified to remove these variables from further SEM analyses. The removal of demographic variables from the structural model is also the research convention in the literature on testing the JD-R model (see for example, Bakker, Demerouti, Taris, Schaufeli & Schreurs, 2003; Bakker, Demerouti & Euwema, 2005; Bakker, Hakanen, Demerouti & Xanthopoulou, 2007; Cullinane et al., 2014; Schaufeli & Bakker, 2004).

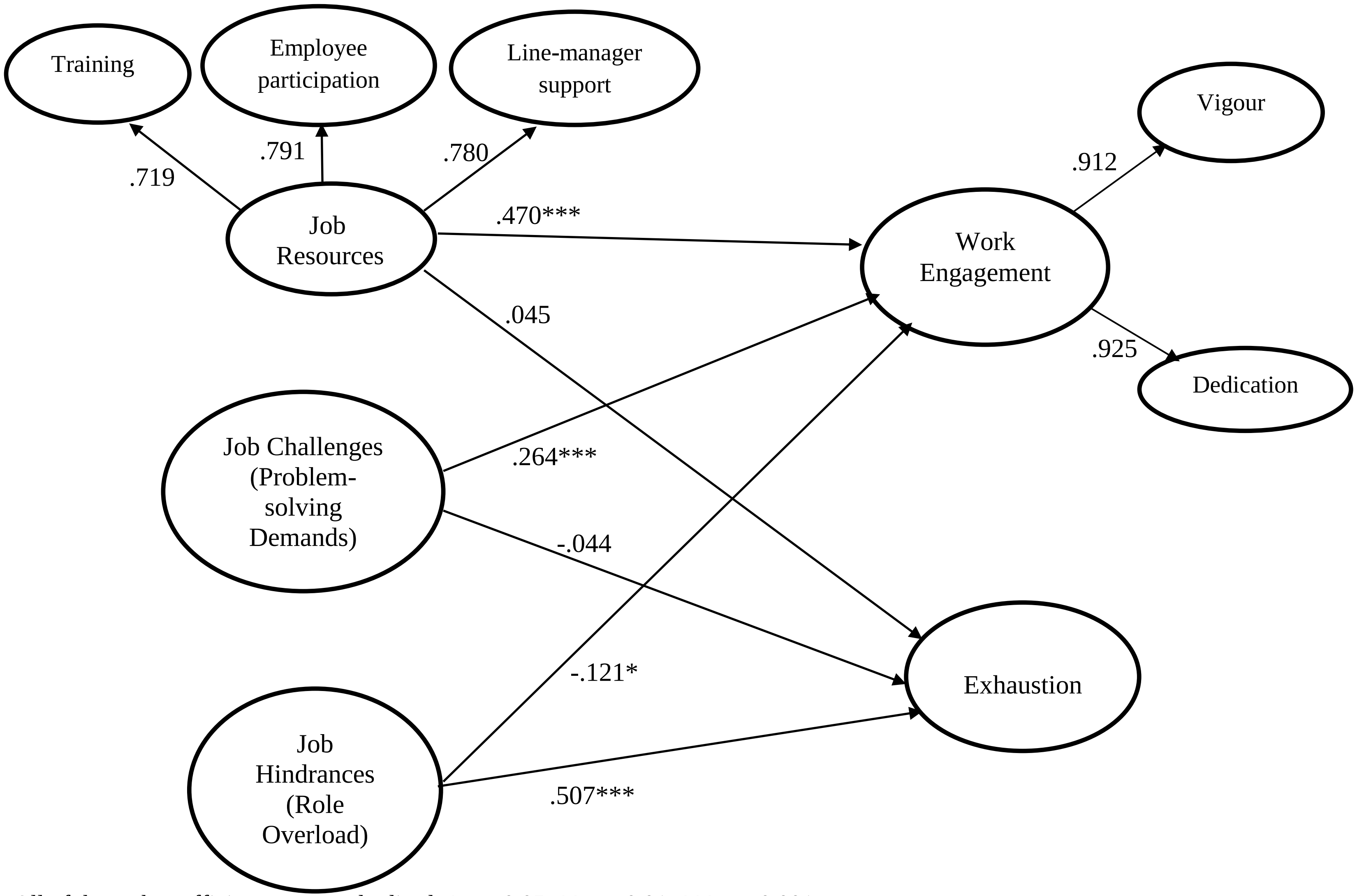
Table 5.5 Means, Standard Deviations, Reliability Coefficients, and Correlations between Study Variables

	Mean	SD	1	2	3	4	5	6	7	8
1. Line manager support	5.02	1.14	(.91)							
2. Problem-solving demands	4.66	.90	.318**	(.72)						
3. Role overload	3.67	1.02	-.128*	.117*	(.74)					
4. Training	4.71	1.30	.482**	.209**	-.208**	(.86)				
5. Employee participation	4.68	1.11	.569**	.280**	-.145**	.484**	(.90)			
6. Task interdependence	5.13	1.15	.413**	.384**	-.032	.357**	.310**	(.84)		
7. Exhaustion	4.58	1.15	-.035	.033	.380**	-.154**	-.110*	.000	(.76)	
8. Work engagement	4.36	1.26	.422**	.363**	-.225**	.474**	.459**	.298**	-.363**	(.93)

N = 371.
*p < .05, **p < .01.
Cronbach's alphas are on the diagonal in bracket.

5.9. Testing the Motivational and Health-Impairment Processes of the JD-R Model

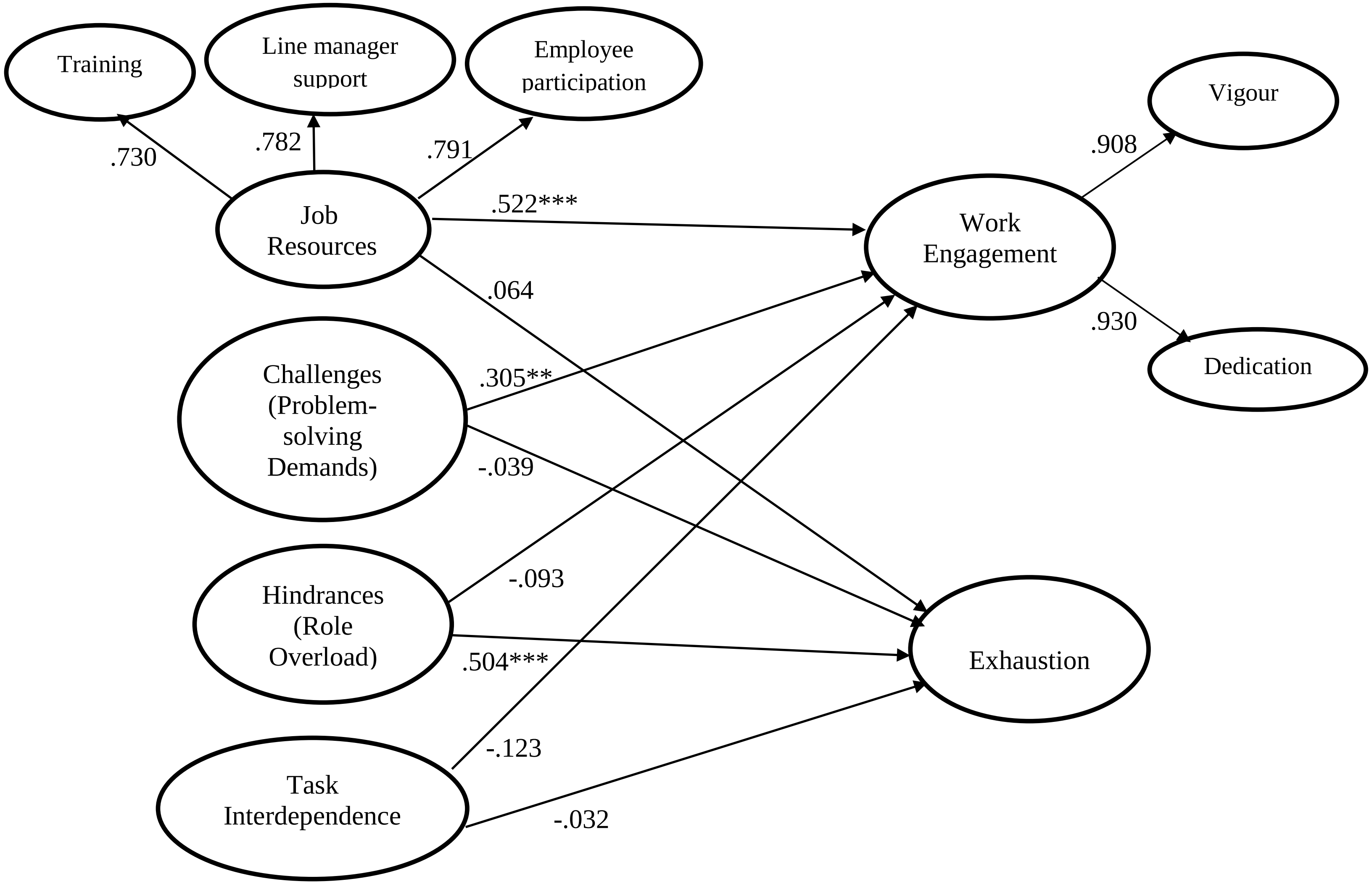
Since the cross-validation of the full multi-factor measurement model was successful, the analysis turned to an assessment of the proposed structural models using the primary sample (i.e. the current 375-worker sample). The first structural model (see Figure 5.1) was set out to test the postulated motivational and health-impairing processes, together with the cross-links between job resources, job challenges and job hindrances on the one hand, and exhaustion and work engagement on the other. This model provided a good fit to the data as evidenced by $\chi^2(390) = 927.016$, CFI = .920, RMSEA = .061 and SRMR = .065. In line with H 1 and H 6, job hindrances (i.e. role overload) were shown to be positively related to exhaustion ($\beta^{standardized} = .507$, $p < .001$) and negatively related to engagement ($\beta^{standardized} = -.121$, $p < .05$). Lean resources was positively related to work engagement ($\beta^{standardized} = .470$, $p < .001$) while its association with exhaustion was found to be non-significant ($\beta^{standardized} = .045$, $p = .600$). Thus, H 3 was supported but H 4 was rejected. Similarly, lean-specific job challenges (i.e. problem-solving demands) was also positively related to work engagement ($\beta^{standardized} = .264$, $p < .001$), yet was not significantly associated with exhaustion ($\beta^{standardized} = -.044$, $p = .573$). Therefore, H 5 was confirmed but H 2 was rejected. The predictor variables in the model jointly accounted for 47.3 per cent of variance in work engagement and 24.9 per cent of the variance in exhaustion. To sum up, these results gave rise to the conclusion that H 1, 3, 5 and 6 are supported but H 2 and 4 are rejected.



Note: All of the path coefficients are standardised; * p < 0.05, ** p < 0.01, *** p < 0.001.

Figure 5.1 The First Structural Model Testing Motivational and Health-Impairment Processes and Cross-Links as Outlined in the JD-R Model

The second structural model (see Figure 5.2) incorporated task interdependence as an independent variable to explain the variability of work engagement and exhaustion. The purpose was to ascertain the role of task interdependence in the prediction of employee wellbeing. This model also fitted the data adequately: $\chi^2(475) = 1131.016$, CFI = .911, RMSEA = .061 and SRMR = .064. As predicted, task interdependence, a characteristic job attribute under lean settings, was found to be unrelated to both engagement ($\beta^{standardized} = -.123$, p = .081) and exhaustion ($\beta^{standardized} = -.032$, p = .693). This fact indicated that task interdependence is neither a job resource nor a job demand when examined in itself. Therefore this construct is outside the scope of the current theoretical model. It was also noteworthy that in the second structural model as shown in Figure 5.2, the direction of all path coefficients relating job resources, challenges and hindrances to engagement and exhaustion remained the same as those presented in the first structural model (see Figure 5.1).



Note: All of the path coefficients are standardised; * p < 0.05, ** p < 0.01, *** p < 0.001.

Figure 5.2 The Second Structural Model Testing the Role of Task Interdependence in the Prediction of Work Engagement and Exhaustion

5.10. Testing the Resources x Challenges/Hindrances Interaction in Predicting Exhaustion

In order to test interaction effects among job resources, job challenges and job hindrances, the latent moderated structural equation (LMS) approach was adopted in the current study as suggested by Cheung and Lau (2015). Using this method is justifiable for two reasons. First, unlike other methods of testing latent interaction effects (e.g. Kenny & Judd, 1984; Joreskog & Yang, 1996; Algina & Moulder, 2001), LMS does not require the calculation of product indicators for the latent interaction term. Therefore, no nonlinear constraints need to be imposed. Second, according to Marsh, Wen, Nagengast, and Hau (2012), LMS is the most accurate method for testing the latent interaction effect because it yields unbiased estimates and standard errors (Klein & Moosbrugger, 2000).

In this section, the analytical procedures that were followed to inspect the interaction effects will be explained. The results are also reported simultaneously. Three steps were required to test the latent interaction effects using the LMS approach. The first step was to estimate a model that only contains the predictor, moderator and outcome variables but excludes the interaction terms. This step is compulsory because the LMS method does not provide data-model fit indices including chi-square test statistics, CFI, SRMR and RMSEA. If this model is found to be a good fit to the data and all of the factor loadings of observed indicators are significant, then the conclusion can be drawn that the observed indicators are adequate for reflecting their respective latent factors. Applying this procedure to the current worker data, I found the first model (i.e. the one as shown in Figure 5.1 without the interaction terms) fitted the data adequately: $\chi^2(390) = 927.016$, CFI = .920, RMSEA = .061 and SRMR = .065. Additionally, all of the factor loadings of observed indicators were significant.

In the second step, the full model with the two interaction terms (i.e. resources x challenges and resources x hindrances interactions) was estimated. In line with Cheung and Lau (2015), the current study employed the bias-corrected bootstrap confidence intervals (hereafter BCCIs) based on 2,000 bootstrap samples as the criterion judging the statistical significance of the interaction effects. The reasoning for this is that the product term of two independent normal distribution variables is not normally distributed (Cheung & Lau, 2015; Hayes, 2013). As a result, using the normal theory methods including the t-test and the Sobel test to determine the significance of the interaction effect is not appropriate (Cheung & Lau, 2015; Geiser, 2010; Hayes, 2013; Jose, 2013). Bootstrapping provides support for the presence of interaction effects if the BCCIs at the 95% level do not cross zero. Table 5.6 and 5.8 display the unstandardized path coefficients, standard errors, t-values, p-values under a normal distribution assumption, together with the lower and upper limits of the 95% and 99% BCCIs for the estimated model parameters. It is clear from Table 5.6 that the relationship between the lean resources/lean challenges interaction and exhaustion is significant at the 1% level (the unstandardized path coefficient = -.917), as evidenced by 99% CI [-2.076, -.273]. This observation validated H 7 that lean job resources buffer the effect of lean job challenges on exhaustion. However, the effect of job hindrances on exhaustion was found not to be moderated by job resources (the unstandardized path coefficient of the interaction term = .232, 95% CI [-.007, .560]). Therefore, H 8 (Lean resources moderate the effect of lean hindrances on exhaustion) was rejected.

Table 5.6 The Interactions between Resources and Challenges/Hindrances in Predicting Exhaustion

	Unstandardized effect	SE	t value	Norm p	95% LL	95% UL	99% LL	99% UL
The main effect of resources	-.024	.146	-.161	.872	-.307	.260	-.400	.364
The main effect of challenges	-.159	.219	-.727	.467	-.736	.179	-.962	.309
The main effect of hindrances	.485	.115	4.221	.000	.288	.743	.234	.826
Resources x challenges interaction	-.917	.321	-2.941	.003	-1.744	-.433	-2.076	-.273
Resources x hindrances interaction	.232	.143	1.629	.103	-.007	.560	-.084	.677

Note: SE= standard error of estimate; Norm p = p value under the assumption of normal distribution; LL = lower limit of confidence interval; UL = upper limit of confidence interval.

Using Aiken, West and Reno's (1991) method, the third step involved graphing the significant interaction plot as identified above. Figure 5.3 shows how lean-specific job resources weaken the effect of job challenges on exhaustion. In line with Cohen and Cohen's (1983) advice, I used -1 standard deviation, the mean, and +1 standard deviation for values of job resources to draw the three simple regression lines labelled as 'Low', 'Medium' and 'High' respectively in the figure. Additionally, simple slope analysis was conducted to confirm that the slopes of the three regression lines in Figure 5.3 are all statistically significant (see Table 5.7). The pattern of these three regression lines as shown in Figure 5.3 lends strong support for the buffering effect of job resources. When job resources were low, at one standard deviation below the mean (-1 SD), the effect of job challenges on exhaustion was significantly positive (.583, 95% CI [.078, 1.156]). When job resources increased to a higher level (the mean value), the impact of job challenges on exhaustion reduced to almost zero (-.159, an effect which was not significantly different from zero according to the 95% CI [-.736, .179]). These results are in line with the buffering hypotheses of job resources in the JD-R model. When job resources grew further, at one standard deviation above the mean (+1 SD), the effect of job challenges on exhaustion became significantly negative (-.902, 95% CI [-1.994, -.344]). This fact implies that the moderator job resources may change the direction of the challenges-to-exhaustion relationship. On the basis of these findings, it is reasonable to conclude that the buffering effect of job resources is tenable.

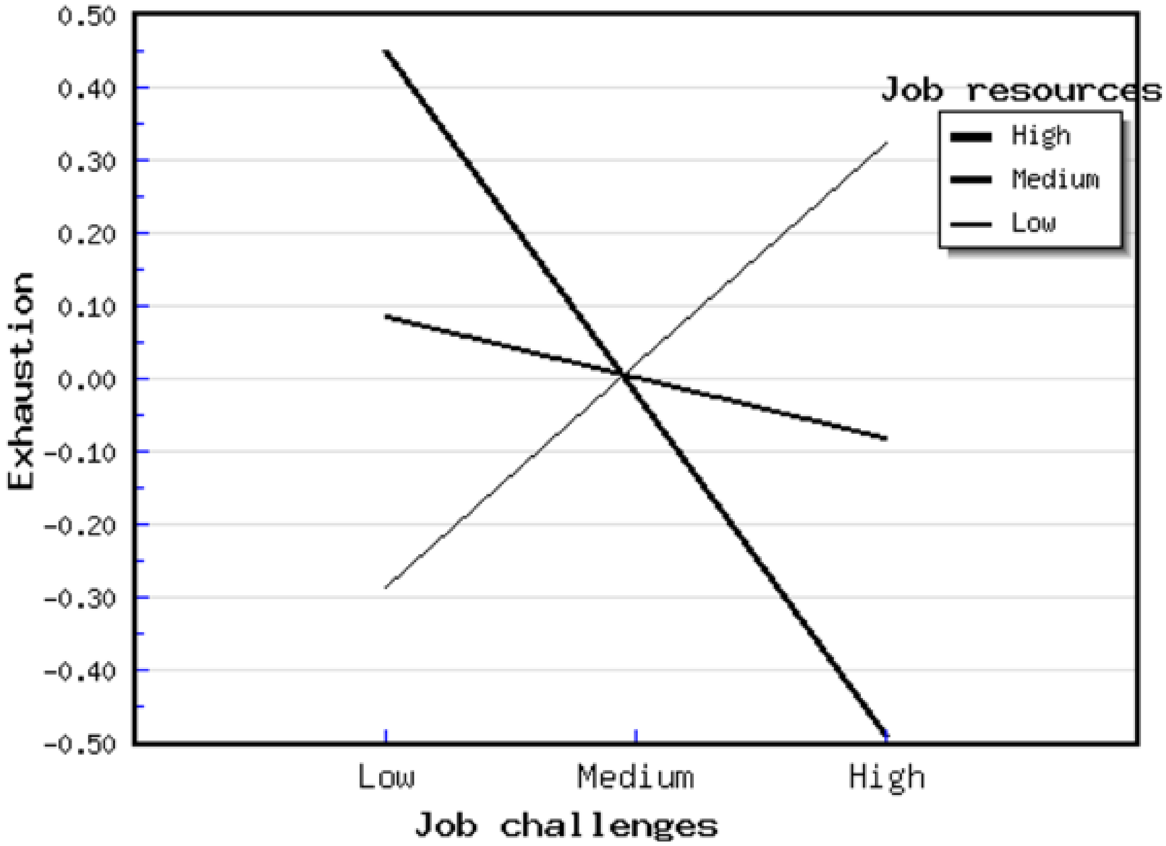


Figure 5.3 Moderation Plot for the Effect of Job Challenges on Exhaustion Moderated by Job Resources

Table 5.7 The Conditional Effects of Job Challenges on Exhaustion at Various Levels of Job Resources

	Job resources	Effect	SE (Boot)	95% BCLL	95% BCUL
+1 SD_R	.810	-.902	.382	-1.994	-.344
Mean R	.000	-.159	.219	-.736	.179
-1 SD_R	-.810	.583	.260	.078	1.156

Note: +1SD_R = one standard deviation above mean; -1SD_R = one standard deviation below mean; R = value of the moderator job resources; SE (Boot) = bootstrap standard error; BCLL = lower limit of bias-corrected bootstrap confidence interval; BCUL = upper limit of bias-corrected bootstrap confidence interval.

5.11. Testing the Resources x Challenges/Hindrances Interaction in Predicting Engagement

The joint effects between resources and demands with regard to engagement were investigated following the same analytical procedures as outlined in the last section. Table 5.8 displays the results of testing the moderating role of challenges/hindrances in the resources-to-engagement relationship. As can be seen from the table, the relationship between the resources x challenges interaction and engagement was statistically significant at the 5% level (the unstandardized path coefficient = .331, 95% CI [.018, .751]). Therefore, H 9, which posited a coping effect of lean job challenges on the job resources-to-engagement relationship, was confirmed. In contrast, the interaction between resources and hindrances in the prediction of work engagement was not significant at the 5% level (the unstandardized path coefficient = -.008, 95% CI [-.159, .168]). On the basis of these findings, it can be concluded that H 10 (Lean hindrances moderate the effect of lean resources on engagement) should be rejected.

Table 5.8 The Interactions between Resources and Challenges/Hindrances in Predicting Engagement

	Unstandardized effect	SE	t value	Norm p	95% LL	95% UL	99% LL	99% UL
The main effect of resources	.743	.186	3.988	.000	.420	1.152	.317	1.351
The main effect of challenges	.624	.247	2.521	.012	.255	1.286	.108	1.587
The main effect of Hindrances	-.124	.091	-1.365	.172	-.302	.055	-.379	.117
Resources x challenges interaction	.331	.185	1.789	.074	.018	.751	-.123	.951
Resource x hindrances interaction	-.008	.082	-.092	.927	-.159	.168	-.223	.255

Note: SE= standard error of estimate; Norm p = p value under the assumption of normal distribution; LL = lower limit of confidence interval; UL = upper limit of confidence interval.

Figure 5.4 is the interaction plot, displaying how job challenges moderate the effect of job resources on engagement. It is clear from this graph that, as the level of job challenges increases, the positive job resources-to-engagement relationship becomes increasingly strong. This empirical fact was further validated by the simple slope analysis, which indicated that all of the three simple regression slopes as shown in Figure 5.4 are statistically significant (see Table 5.9). Therefore, it is safe to draw the conclusion that the coping effect of job challenges in the resources-to-engagement relationship as predicted in H 9 should be confirmed.

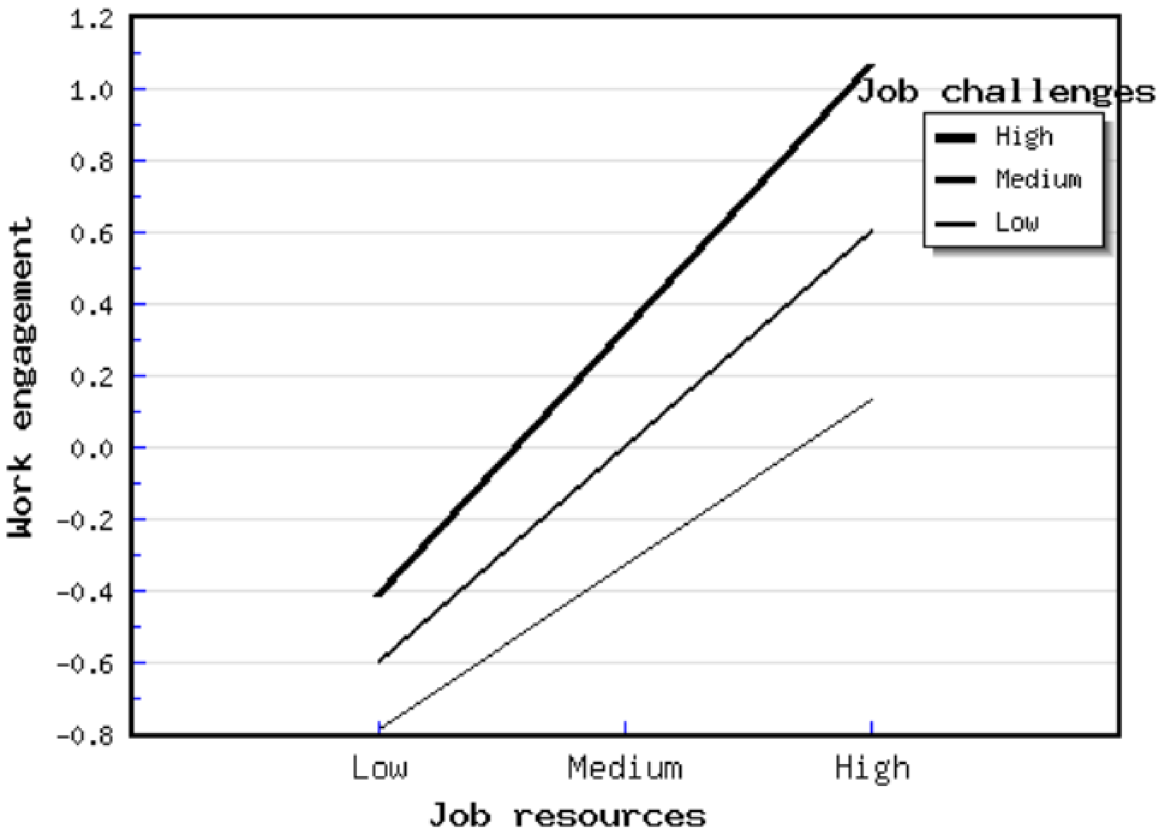


Figure 5.4 Moderation Plot for the Effect of Job Resources on Work Engagement Moderated by Job Challenges

Table 5.9 The Conditional Effects of Job Resources on Engagement at Various Levels of Job Challenges

	Job challenges	Effect	SE (Boot)	95% BCLL	95% BCUL
+1 SD_R	.522	.915	.251	.464	1.459
Mean R	.000	.743	.186	.420	1.152
-1 SD_R	-.522	.570	.156	.290	.904

Note: +1SD_R = one standard deviation above mean; -1SD_R = one standard deviation below mean; R = value of the moderator job challenges; SE (Boot) = bootstrap standard error; BCLL = lower limit of bias-corrected bootstrap confidence interval; BCUL = upper limit of bias-corrected bootstrap confidence interval.

5.12. Overview of the Key Findings from the Worker Survey

The following six hypotheses were confirmed in the worker data: (H 1) lean-specific job hindrances are positively related to exhaustion; (H 3) lean-specific resources are positively related to work engagement; (H 5) lean-specific job challenges are positively related to work engagement; (H 6) lean-specific job hindrances are negatively related to work engagement; (H 7) lean-specific job resources buffer the adverse effect of lean job challenges on exhaustion; and (H 9) lean-specific job challenges moderate the effect of lean-specific job resources on work engagement such that the effect is increased in the presence of high job challenges.

In contrast, the remaining four hypotheses were rejected. They were: (H 2) lean-specific job challenges are positively related to exhaustion; (H 4) lean-specific job resources are negatively related to exhaustion; (H 8) lean-specific job resources buffer the detrimental effect of lean-specific job hindrances on exhaustion; and (H 10) lean-specific job hindrances moderate the positive effect of lean-specific job resources on work engagement such that the effect is increased at the presence of high job hindrances.

6. Chapter Six: Results from the Line Manager Survey

The present chapter, consisting of eight sections, reports survey findings regarding line managers' work experiences under lean production. The first section presents the background information of the participants. The second section elaborates on the results from data screening. This is followed in the third section by an examination of whether the survey data meet the statistical assumptions underlying multiple regression. Results of testing the severity of common method bias are reported in the fourth section. The correlation matrix involving all of the variables is provided in the fifth section. The remaining two sections report the statistical results for each of the hypotheses.

6.1. Demographic Characteristics of the Survey Participants

The survey was initially administered to all of the line managers in the case company (N = 103) and 94 of them completed and returned the survey, leading to a total response rate of 91 per cent. Respondents were all males. This is consistent with the gender composition of the line-manager population in the company, as reported by the general manager. The mean age of the sampled managers was 34.88 years (SD = 7.83). Of managers, 3.7 per cent were born in the 1990s and 56.8 per cent were born in the 1980s, 35.8 per cent in the 1970s and the rest (3.7 per cent) were born before the 1970s. The mean value of job tenure was 10.10 years (SD = 7.14): 22.9 per cent of the managers have been working in the company for five years or less, 45.8 per cent have been there between six and ten years, 20.5 per cent have been employed between eleven and twenty years, and the remaining managers (10.8 per cent) have been working there for more than twenty years. In terms of the educational level, 34.4 per cent of the managers had only completed high school, 58.4 per cent had obtained a technical and vocational education, 3.6 per cent had a college education and the remaining 3.6 per cent held a university degree.

6.2. Data Screening

The raw data were first screened in SPSS to ascertain the accuracy of the data file and identify the magnitude of missing data. Frequency tables and descriptive statistics for each variable were produced to check for mistyping and out-of-range values. All of the values were within the range, and means and standard deviations were also plausible. The magnitude of missing values was examined using the missing value analysis in SPSS. Of the total 94 observations, 62 per cent had no missing data and a further 34 per cent had three or fewer missing responses. In view of this small quantity of missing observations, I decided to work with the available data rather than estimating missing values.

6.3. Statistical Assumption Testing

As with SEM, multiple regression analysis also has a number of assumptions, including no perfect multicollinearity, homoscedasticity, linearity and normal distribution of residuals (the differences between the model-implied and observed outcome variable values) (Tabachnick & Fidell, 2014). No perfect multicollinearity means that predictor variables should not correlate too highly with each other (i.e. Pearson correlation > .90). After scanning the correlation matrix of all the predictor variables in the current study, it was found that no correlations were above .60 and thus the assumption related to multicollinearity was met.

Homoscedasticity implies that at any given level of the predictor variables, the variance of the residual terms ought to be the same. Linearity requires that the relationship between predictors and outcome variables estimated in multiple regression should be a linear one (Field, 2013). Whether these two assumptions were met was determined by drawing two types of regression plots. The first is a series of bivariate scatter-plots of pairs of the variables. The results showed that all of the scatterplots were oval-shaped and of approximately the same width all over with some bulging towards the middle. This fact lent strong support for concluding that the relationships between variables are linear and homoscedastic (Tabachnick & Fidell, 2014). This conclusion was also confirmed by residuals' plots where standardized residuals are plotted against the standardized model-implied values of outcome variables. These residuals' plots showed that all of the dots were randomly and evenly distributed around zero, indicating that the assumptions of homoscedasticity and linearity have been fulfilled.

The normality of residuals is the last important assumption underlying multiple regression. It refers to the requirement that the residuals in the model ought to be random, normally distributed variables with a mean value of zero. To test this assumption, both a histogram and an expected normal probability plot of the standardized residuals were generated. A visual inspection of these two plots suggested that the residuals in the current data were normally distributed. This was evidenced by the fact that the distribution of residuals on the histogram was symmetrical and the observed residual points in the probability plot all lay closely to the ideal diagonal line.

As the final step of testing the statistical assumptions, box-plots and histograms with normal distribution overlays were produced for each variable to ascertain potential univariate outliers. Although a small number of potential outliers was identified from the box-plots, an examination of the data file revealed that they were extreme but legitimate scores rather than outliers. Therefore, all of these cases were retained.

6.4. Testing the Severity of Common Method Bias

Since the line manager data were also collected using self-report surveys, I adopted Harman's one-factor test to diagnose the severity of the issue of common method bias. All of the measurement items in the survey were entered into an un-rotated exploratory factor analysis. According to Podsakoff, MacKenzie and Podsakoff (2012), if a considerable amount of common method variance exists, either a single factor will emerge or one general factor will explain most of the covariance among the measured variables. After entering all of the items into the exploratory factor analysis model, nine factors were extracted from the analysis. The first factor explained only 21.82 per cent of the total variance. No general factor appeared from the analysis. On this basis, it was concluded that the common method issue was unlikely to have biased the current survey results.

6.5. Descriptive Statistics

Table 6.1 lists the means, standard deviations, correlations and the reliability coefficients (i.e. Cronbach's alpha) of the variables used in the study. It provides preliminary support for the various hypotheses established in the study. For example, all indicators of job resources (i.e. method autonomy, decision-making autonomy, training and top management support) are positively associated with engagement to a significant extent. In addition, hindrance demands (role overload) are significantly positively related to exhaustion. These results are consistent with the motivational and health-impairing processes of the JD-R model. Also of note is the fact that the demographic variables (i.e. age and organisational tenure) are not significantly related to either of the two outcome variables. In view of this observation, the decision was made to leave out these two demographic variables in the following data analysis in order to avoid misinterpretation of the results (Spector & Brannick, 2011).

It should be noted that each variable in the current line-manager dataset was measured using the composite score formed by averaging the sum of item responses which reflect that variable of interest. Results of reliability analysis showed that the reliability coefficients (i.e. Cronbach's alpha) exceeded .70 for all of the measurement scales, indicating good scale reliability (Kline, 2011). This fact suggested that all of the measuring scales have adequate internal consistency. On this basis, it is justified to combine all of the constituent items within each scale into a composite score.

Table 6.1 Means, Standard Deviations, Reliability Coefficients, and Correlations between Variables

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. Age	34.88	7.83	-											
2. Tenure	10.10	7.14	.565**	-										
3. Task interdependence	5.42	.85	-.016	-.136	(.83)									
4. Problem-solving demands	4.76	.91	.040	-.164	.283**	(.81)								
5. Job complexity	4.19	1.25	.196	.162	.143	-.061	(.82)							
6. Work method autonomy	4.16	1.37	-.096	.061	.282**	.165	-.001	(.92)						
7. Top management support	4.91	1.14	-.190	-.154	.223*	-.112	-.009	.354**	(.94)					
8. Training	5.06	1.19	-.037	-.153	.163	.170	-.129	.285**	.531**	(.87)				
9. Decision-making autonomy	4.27	1.24	-.169	-.142	.378**	.000	-.070	.532**	.467**	.250*	(.80)			
10. Role overload	3.99	1.06	-.167	-.102	.103	.341**	-.421**	.201	-.111	-.122	.057	(.79)		
11. Exhaustion	4.40	1.12	-.117	-.051	.201	.275**	-.144	.112	-.141	-.148	.061	.375**	(.81)	
12. Engagement	4.83	1.21	.125	-.027	.160	.017	.315**	.214*	.226*	.287**	.230*	-.319**	-.553**	(.94)

N = 94.
*p < .05, **p < .01.
Cronbach's alphas are on the diagonal in bracket.

6.6. Testing the Motivational and Health-Impairment Processes of the JD-R Model

Two path models were specified to test the various hypothesized relations among study variables. The first path model investigated the motivational and heath-impairing processes of the JD-R model. To this end, all of the resource and demand indicators were modelled as independent variables to predict work engagement and exhaustion. It was at this point that the postulated cross-links between job resources and exhaustion, and between job demands (including both challenges and hindrances), and work engagement were also investigated. The second path model examined the interaction effects between job resources and challenge demands, and between job resources and hindrance demands. In this model, job resource indicators, job demand indicators, and all possible pairs of their product terms were specified as independent variables predicting work engagement and exhaustion. In line with Aiken, West and Reno (1991), all of the resource and demand indicators were mean-centred before they were multiplied by each other to form the interaction terms.

The path coefficients estimated in the first model are displayed in Table 6.2. Two hypotheses associated with the health-impairment process of the JD-R model were tested in the current study, one positing a positive hindrances-to-exhaustion nexus (H 1) and the other predicting a positive challenges-to-exhaustion relationship (H 2). The path analysis results shown in Table 6.2 indicated that H 1 was supported (role overload: $\beta^{standardized}$ = .231; p = .044), whereas H 2 was rejected (problem-solving demands: $\beta^{standardized}$ = .155; p = .150; job complexity: $\beta^{standardized}$ = -.080; p = .463). The motivational process (H 3) of the JD-R model, which proposes a positive relationship between resources and engagement, was partially confirmed. This was evidenced by the fact that only the training component of job resources was significantly related to engagement ($\beta^{standardized}$ = .223; p = .048) whereas the other forms of resource were not predictive of work engagement, including top management support ($\beta^{standardized}$ = -.025; p = .833), work-method autonomy ($\beta^{standardized}$ = .115; p = .301) and decision-making autonomy ($\beta^{standardized}$ = .151; P = .195). This observation suggested that different job resources were valued by line managers differently, with training being the most useful and effective resource in promoting their work engagement.

As for the postulated negative cross-link between job resources and exhaustion, this hypothesis (H 4) was rejected because none of the resource indicators demonstrated a significant path coefficient in predicting exhaustion (top management support: $\beta^{standardized}$ = -.083, p = .499;

decision-making autonomy: $\beta^{standardized}$ = .033; p = .787; work-method autonomy: $\beta^{standardized}$ = .052, p = .653; training: $\beta^{standardized}$ = -.162; p = .169). Regarding the posited positive cross-link between challenge demands and engagement (H 5), this hypothesis was partially confirmed. As can be seen from Table 6.2, of the two indicators of job challenges, only job complexity displayed a significantly positive path coefficient ($\beta^{standardized}$ = .256; p = .013), whereas the other challenge indicator (i.e. problem-solving demands) was found to be unrelated to work engagement ($\beta^{standardized}$ = .050; p = .633). In addition, it was found that the hindrance demands (i.e. role overload) were inversely related to engagement to a significant degree ($\beta^{standardized}$ = -.237; p = .032). This fact supported the tenability of H 6, which postulated a negative relationship between hindrance demands and work engagement. Overall, the hypothesized path model as displayed in Table 6.2 accounted for 27.7 per cent of the variance in work engagement and 21.7 per cent of the variance in exhaustion.

Another finding worth mentioning was the non-significant path coefficients relating task interdependence to engagement ($\beta^{standardized}$ = .014; p = .893) and to exhaustion ($\beta^{standardized}$ = .163; p = .125). This fact confirmed the assumption that task interdependence, when examined by itself, neither enhances nor inhibits wellbeing directly. Therefore, task interdependence should not be classified into either job resource or job demand group.

Table 6.2 The Path Coefficients Estimated in the First Model of Testing the Motivational and Health-Impairment Processes

Model	Predictors	Work engagement	Exhaustion
		Path coefficient ($\beta^{standardized}$)	Path coefficient ($\beta^{standardized}$)
1	Role overload	-.237*	.231*
	Problem-solving demand	.050	.155
	Task interdependence	.014	.163
	Job complexity	.256*	-.080
	Decision-making autonomy	.151	.033
	Work method autonomy	.115	.052
	Top management support	-.025	-.083
	Training	.223*	-.162

Note: N = 94; * $p < .05$.

6.7. Testing the Interaction between Job Resources and Job Demands

Table 6.3 reports the statistical results of testing the interaction effects among job resources, hindrances and challenges in predicting work engagement and exhaustion. In line with the standard practice in the literature (see, for example, Wayne, Lemmon, Hoobler, Cheung & Wilson, 2016), the bias-corrected bootstrap confidence interval (BCCI) based on 1,000 bootstrap samples was used as the criterion for determining the presence of the interaction effects. Bootstrapping offers evidence of interaction effects if the BCCIs at the 95% level do not cross zero. The conventional significance tests such as the t-test and the Sobel test that assume data normality, were not applicable here because the interaction term, calculated as the product of the independent variable and the moderator, is not normally distributed (Cheung & Lau, 2015; Geiser, 2012; Hayes, 2013). Statistical results showed that none of the hypotheses related to the interaction effects was supported in the current study. This conclusion was drawn based on the fact that all of the 95% confidence intervals for the interaction effects contained zero. The rejected hypotheses included: H 7 (lean job resources buffer the challenges-to-exhaustion relationship), H 8 (lean job resources buffer the hindrances-to-exhaustion relationship), H 9 (lean job challenges moderate the resources-to-engagement relationship), and H 10 (lean job hindrances moderate the resources-to-engagement relationship).

Table 6.3 The Unstandardized Interaction Effects among Resources, Challenges and Hindrances in Predicting Work Engagement and Exhaustion

Predictors	Work engagement				Exhaustion			
	Effect	Norm p	95% BCLL	95% BCUL	Effect	Norm p	95% BCLL	95% BCUL
Top management support x overload	.214	.424	-.286	.796	-.051	.816	-.471	.386
Method autonomy x overload	.072	.685	-.211	.452	-.047	.784	-.374	.245
Decision-making autonomy x overload	-.149	.555	-.711	.274	.291	.257	-.223	.664
Training x overload	-.314	.205	-.771	.130	.185	.380	-.251	.555
Training x interdependence	-.151	.537	-.746	.229	.286	.287	-.099	.858
Decision-making autonomy x interdependence	-.009	.974	-.509	.492	.019	.941	-.520	.607
Method autonomy x interdependence	.086	.710	-.356	.527	.132	.469	-.200	.513
Top management support x interdependence	.193	.464	-.278	.756	-.112	.648	-.598	.394
Top management support x problem-solving demand	-.289	.315	-.913	.256	.063	.829	-.411	.805
Method autonomy x problem-solving demand	.057	.786	-.439	.419	-.131	.505	-.564	.226

Decision-making autonomy x problem-solving demand	-.032	.895	-.441	.557	-.009	.967	-.434	.418
Training x problem-solving demand	.205	.459	-.367	.732	-.110	.653	-.607	.359
Top management support x job complexity	.281	.209	-.124	.796	-.283	.284	-.838	.183
Method autonomy x job complexity	-.077	.624	-.389	.230	.129	.547	-.318	.527
Decision-making autonomy x job complexity	.083	.649	-.341	.400	-.060	.757	-.396	.210
Training x job complexity	-.027	.876	-.304	.414	.009	.955	-.527	.257

Note: Norm p = p value under the assumption of normal distribution; BCLL = lower limit of bias-corrected bootstrap confidence interval; BCUL = upper limit of bias-corrected bootstrap confidence interval.

6.8. Overview of the Key Findings from the Manager Survey

This chapter reported the results of path analysis based on the line manager data. The following four hypotheses were supported: (H 1) lean job hindrances are positively related to exhaustion; (H 3) lean-specific resources are positively related to work engagement; (H 5) lean-specific challenges are positively related to work engagement; and (H 6) lean job hindrances are negatively related to work engagement.

By contrast, the remaining six hypotheses were rejected. These include: (H 2) lean job challenges are positively related to exhaustion; (H 4) lean job resources are negatively related to exhaustion; (H 7) lean job resources buffer the effect of lean job challenges on exhaustion; (H 8) lean job resources buffer the effect of lean job hindrances on exhaustion; (H 9) lean job challenges moderate the effect of lean job resources on engagement such that the effect is enhanced under high levels of job challenges and (H 10) lean job hindrances moderate the effect of lean job resources on engagement such that the effect is strengthened at the presence of high job hindrances.

7. Chapter Seven: Discussion

This chapter comprises seven parts. Part one revisits the key findings from the worker survey. The discussion within this part has been structured around three themes that emerged from the survey results: 1) the motivational process from different types of lean job characteristics to work engagement; 2) the health impairment process from various lean job characteristics to exhaustion; and 3) the interaction among job resources, job challenges and job hindrances in the prediction of work engagement and exhaustion. Part two deals with the interpretation of findings that were derived from the line manager survey. The discussion in this part is organised into the same three themes as in part one. Part three and part four compares and contrasts findings from both surveys. This is followed by an elaboration on the strengths and limitations of the current study in part five and part six respectively. Both the theoretical and practical implications of the present study will be discussed in part seven.

7.1. Part One: Interpretation of Key Findings from the Worker Survey

7.1.1. The Motivational Process from Lean Job Characteristics to Work Engagement

This section discusses Hypotheses 3, 5 and 6 regarding the relationships of job resources, job challenges and job hindrances with work engagement. The results support the postulated positive relationships between job resources and challenge demands, on the one hand, and work engagement, on the other. In addition, the negative association between hindrance demands and work engagement was also evident from the worker survey data. These findings are important for two reasons. First, they confirm the argument of the JD-R theory that job resources are the most important predictors of work engagement (Bakker, Demerouti, De Boer & Schaufeli, 2003; Bakker, Demerouti & Verbeke, 2004). Second, they support Podsakoff et al.'s (2007) argument that the relationship between job demands and engagement depends on the nature of the demand such that challenge demands are positively related to engagement whereas hindrance demands are negatively related to engagement. As a result, it is necessary to break down the job demand construct into the challenge and hindrance sub-groups in order to better understand the inconsistent findings of previous studies regarding the relationship between job demands and work engagement. According to Crawford et al. (2010), some job demands labelled as challenges (e.g. job complexity and problem-solving demands) are positively valued by employees because they can fulfil people's psychological needs such as mastery and personal growth. Thus, in line with the current study, a number of empirical works in the literature have shown that challenge demands can motivate employees to stay engaged (Bakker & Sanz-Vergel, 2013; Podsakoff et al., 2007; Van den Broeck et al., 2010). In contrast, other types of job demands categorized as job hindrances are negatively perceived by employees as barriers and constraints because they hinder personal growth, leaning and goal accomplishment. Therefore empirical studies have reported that hindrance demands such as interpersonal conflict and role overload are negatively related to work engagement (Dawson, O'Brien & Beehr, 2015; Crawford et al., 2010). The current research findings lend further support to this body of literature.

7.1.2. The Health-Impairing Process from Lean Job Characteristics to Exhaustion

Regarding the relationships between the three types of lean job attributes and exhaustion, the current study posited that the availability of job resources reduces exhaustion whereas both challenge and hindrance demands increase exhaustion. However, the survey data yielded mixed supports for these hypotheses. Only job hindrances showed a statistically significant positive relation with exhaustion (H 1). This empirical fact is congruent with existing literature supporting the detrimental effect of hindrance demands on employee wellbeing. For example, a 101-sample meta-analysis by LePine, Podsakoff and LePine (2005) found evidence that job hindrances have positive effects on strains measured by emotional exhaustion, anxiety, illness and physical symptoms. More recently, Clarke (2012) conducted another meta-analytic study with 46 independent samples to investigate how challenge and hindrance stressors influence employee workplace wellbeing, as indicated by occupational injuries and near-misses (where an injury is avoided by a narrow margin). The results showed that job hindrances (e.g. role overload and office politics) related positively to work injuries and near misses.

The current survey data failed to identify any statistically significant cross-linkages of challenge demands and job resources with exhaustion (H 2 and H 4). This observation may suggest that the particular resources provided by management in this lean manufacturer are not well targeted at the job demand of role overload while employee involvement in problem-solving is having something of a neutral impact on exhaustion. Following the recommendation by Van den Broeck et al. (2010), I further conducted a complementary analysis by estimating an alternative model in which only challenge demands and hindrance demands were included to predict engagement and exhaustion. The analysis yielded the same result that the relationship between job challenges and exhaustion was still non-significant. However, obtaining these non-significant findings in the current study is not surprising because the same results have been reported elsewhere in the literature. In a survey of 261 Dutch call centre operators, Van den Broeck et al. (2010) showed similar findings that both job resources (indicated by social support and autonomy) and challenge demands (measured by cognitive demands) were unrelated to exhaustion. Further, Boyd, Bakker, Pignata, Winefield, Gillespie and Stough (2011) have conducted a longitudinal study, reporting the same non-significant health-impairment effect of job demands as proposed in the JD-R model. Specifically, by surveying a sample of 296 Australian academic employees on two occasions three years apart, the researchers found that Time 1 demands (reflected by work pressure and workload) were not associated with Time 2 psychological strain (measured by anxiety, social dysfunction and loss of confidence). More recently, in a two-wave survey of 9,404 workers from both Australia and China, Brough et al. (2013) replicated Boyd et al's (2011) longitudinal results of a non-significant health-impairing process of the JD-R model.

Turning back to the current study, I believe that the finding of a non-significant relationship between job challenges and exhaustion is reasonable, considering the role of mental fatigue as the antecedent of exhaustion (Demerouti, Bakker, Nachreiner & Ebbinghaus, 2002). In a survey-based study of 294 German workers from a cross-section of industries, Demerouti et al. (2002) found that workers develop mental fatigue as an immediate reaction to the demanding work conditions whereas feelings of exhaustion will be produced only after they continuously experience repeated, non-compensated and intensive mental fatigue over a long period of time. On the strength of this finding, I argue that job demands do not necessarily lead to exhaustion if workers' mental fatigue can be alleviated in a timely manner before it accumulates to form feelings of exhaustion. According to Demerouti et al. (2002), recovery from mental fatigue can be accomplished by giving workers sufficient rest breaks. A comparable explanation was provided by Schaufeli and Taris (2014), who argued that when job demands are high, extra effort must be spent to cope with the demands. This comes with physical and psychological costs, such as fatigue. However, workers can recover from consuming this additional energy and the associated costs provided that they are given adequate breaks. That is to say, exhaustion will result only if recuperation is inadequate for workers. Drawing on the findings from worker interviews, I believe that the provision of rest breaks is a possible reason for why no positive relationship between challenge demands and exhaustion was identified in the current worker data. To elaborate, the worker interviewees reported that, as a result of the company's adoption of flexible work schedules, they have experienced more frequent short breaks that were evenly distributed in a working day. This increased frequency of work breaks is likely to have alleviated the fatigue symptoms and ultimately negated the impact of job challenges on exhaustion.

The current worker data also showed a non-significant relation between job resources and exhaustion (H 4). A plausible explanation derives from conservation of resource theory (Hobfoll, 1989). According to the theory, people react to resource loss (i.e. job demands) more strongly than resource gain. This implies that, given the same amounts of loss and gain, resource loss will create a bigger negative impact on employee wellbeing. Following this line of thoughts, it then becomes logical why providing workers with adequate job resources may not necessarily contribute to decreased exhaustion. The reason is that workers' exhaustion symptoms are more sensitive to resource loss (i.e. job demands) than to resource gain.

7.1.3. The Interaction Effects among Resources, Challenges and Hindrances

Another objective of the current study was to test the interaction propositions of the JD-R model. To this end, four hypotheses (H 7 through H 10) were established, investigating the interactive effects among lean resources, challenges and hindrances with regard to engagement and exhaustion. The results of moderated SEM supported two of the four hypotheses associated with challenge demands (i.e. H 7 and H 9). Specifically, one is the buffering effect of job resources in the challenges-to-exhaustion relationship (H 7), suggesting that challenge demands are less likely to produce exhaustion when adequate job resources are provided. This finding is in line with that of Bakker, Demerouti and Euwema's (2005) study in which 1,012 employees from a Dutch university were surveyed and the moderation by job resources (e.g. social support and autonomy) of the job demands-to-exhaustion relationship was identified (job demands were measured by a mixture of both challenges and hindrances including work overload, emotional demands, physical demands and work-home interference). The confirmation of this interaction effect suggests that, in the current case company, resources of training, opportunities to participate in decision-making and line-manager support are effective in strengthening workers' abilities to meet the challenge of the greater problem-solving demands. This fact highlights the importance of matching resources to the specific demands being encountered.

The other interaction hypothesis validated in the current study is the coping effect of job challenges in the resources-to-engagement relationship (H 9). This finding confirms that job resources become most useful and demonstrate the strongest positive influence on engagement when job challenges are high. Similar results were provided by Cullinane et al.'s (2014) questionnaire survey of 200 pharmaceutical manufacturing workers. Practically, this finding implies that it is under stressful conditions that employees will more likely need job resources to cope with existing demands and to reduce stress (Demerouti & Bakker, 2011).

On the contrary, there was no evidence in the present study for the interaction between lean resources and hindrance demands in analyses of both exhaustion (H 8) and work engagement (H 10). This result may imply that the current resources provided by management are not well targeted at the hindrance demands (role overload in this case), which are more concerned with the volume and pace of work. These findings contribute to the literature with new knowledge about the distinction between job challenges and job hindrances. Studies to date have only identified their different effects in the prediction of work engagement. The current study goes one step beyond earlier research by showing that the possibility of detecting a moderation effect is higher when the particular demand under investigation is of a challenging nature. A plausible explanation for this is that hindrance demands are evaluated by workers as barriers to their personal growth, learning and goal accomplishment that are difficult, if not impossible, to overcome no matter how much effort they invest. As a result, in the face of job hindrances, individuals may resort to a passive, disengaging style of coping and refuse to apply job resources to deal with them (Crawford et al., 2010). This logic explains why the resources x hindrances interaction effects in predicting both exhaustion and work engagement were found non-significant in the current data set. In contrast, challenge demands are viewed by workers as opportunities to enhance competence, personal growth and future gain (Schaufeli & Taris, 2014). Therefore, when faced with job challenges, workers are more willing to use their job resources to cope with challenge demands in the belief that successful coping with these challenges will bring further resource gains. This reasoning enables us to better understand why the resources x challenges interaction effects in explaining exhaustion and work engagement were confirmed in the current worker data. These results from testing the moderation hypotheses imply that job challenges and job hindrances should be differentiated and examined separately, when testing the resources x demands interaction effect in future research.

To sum up, two of the four interaction hypotheses were rejected in the worker data. This fact confirmed Schaufeli and Taris's (2014) observation that the evidence in the literature for joint effects between demands and resources is rather weak. Likewise, Taris (2006) described this interaction as a fickle phenomenon based on the fact that only nine of 90 tests conducted in the literature found evidence for the interaction effect between job resources and job demands. Indeed, the majority of previous studies testing the JD-R framework yielded non-significant moderation effects of both resources and demands (see Brough et al., 2013; Cullinane et al., 2014; Hallberg, Johansson & Schaufeli, 2007; Llorens, Bakker, Schaufeli & Salanova, 2006; Schaufeli & Bakker, 2004; Schaufeli, Taris & Van Rhenen, 2008).

For example, Hu et al. (2011) conducted a survey of 625 Chinese blue-collar workers from three mechanical factories to examine the joint effects of demands and resources. The survey results showed that job resources (including job control, supervisory coaching and colleague support) did not buffer the effect of job demands (including workload, emotional demands, physical effort and interpersonal conflict) on exhaustion. As another illustration of non-significant interactive effects between resources and demands, Brough et al. (2013) conducted a cross-cultural longitudinal study by surveying 5,248 Australian employees and 4,156 Chinese employees from a variety of industries on two occasions with a twelve-month time lag. The results from both wave-one and wave-two surveys across the two countries showed no evidence for the interaction between demands and resources with regard to engagement and psychological strain. The explanation for this finding provided by Brough et al. (2013) is that job demand-by-job resource interactions are unlikely to occur at random in predicting employee wellbeing. Instead, the possibility of finding significant interactions is increased only if the job demand, job resource and wellbeing variables all come from the same domain of human psychological functioning (including cognitive, emotional and physical domains).

The triple-match principle (TMP) (De Jonge & Dormann, 2003) provides a rationale to help us understand why it is difficult to detect the interaction effects in empirical studies. There are two primary propositions in the TMP. One is that job demands, job resources and wellbeing outcomes are each multi-dimensional concepts including behavioural, cognitive and emotional components. The other proposition is that strong interactions between job resources and job demands in predicting wellbeing outcomes can be observed only if all of the variables involved come from qualitatively identical dimensions. To elaborate, referring to the first principle, cognitive demands and cognitive resources are more likely to affect cognitive forms of strains, emotional demands and emotional resources are more likely to influence emotional forms of strains, and finally, behavioural demands and behavioural resources are more likely to impact on behavioural (physical) forms of strains. This is what ‘triple match’ stands for.

Drawing on the TMP, it becomes logical that the current survey results have rejected half of the interaction hypotheses. This is because the job resource variables included in the present study did not match very well with the job demand indicators. As suggested by the TMP, strong interaction effects can be observed only when specific resources match with specific demands from the same domain (De Jonge & Dormann, 2003). However, the present study employed composite job resources formed by a mixture of behavioural, emotional and cognitive resources.

This measurement approach is likely to have obscured the differential effect of specific resource components from distinct domains (Hu et al., 2011; Van den Tooren & De Jonge, 2008).

7.2. Part Two: Interpretation of Key Findings from the Line Manager Survey

The current managerial study examined two core propositions of the JD-R model (i.e. the motivational process and the health-impairing process) and the interaction effects among job resources, challenge demands and hindrance demands. Path analysis was applied as the primary data analytic technique. The results supported both the health-impairing (H 1) and the motivational (H 3 and H 5) processes of the JD-R model, together with the negative cross-link between job hindrances and engagement (H 6). In contrast, the remaining two cross-links between job challenges and exhaustion (H 2), and between job resources and exhaustion (H 4), and all of the hypothesized interaction effects (H 7 through H 10) were rejected.

7.2.1. Validating the Motivational Process

In line with the motivational process of the JD-R model (Bakker, Hakanen, Demerouti & Xanthopoulou, 2007), the current study proposed three associated hypotheses: a positive resources-to-engagement relationship (H 3), a positive challenges-to-engagement relationship (H 5) and a negative hindrances-to-engagement relationship (H 6). The managerial survey findings provided evidence for all of these three hypotheses. To elaborate, job hindrances, as measured by role overload, were negatively related to engagement for the sampled managers. When training and job complexity served as the proxy for job resources and job challenges respectively, they were shown to be statistically significant predictors of work engagement. However, other forms of resources (i.e. top management support, work method autonomy and decision-making autonomy) and job challenges (i.e. problem-solving demands) were found to be unrelated to engagement. The lesson learnt from this observation is that the specific type of job resource and job challenge is likely to make a difference in predicting employee wellbeing. Overall, the current study in lean settings offered support to previous empirical works which have confirmed the tenability of the motivational process in the JD-R model (e.g. Bakker, Demerouti & Schaufeli, 2003; Bakker, Demerouti, de Boer & Schaufeli, 2003; Schaufeli & Bakker, 2004).

7.2.2. Validating the Health-Impairment Process

The health-impairing process of the JD-R model proposes that job demands (including challenge and hindrance demands) are the most important determinants of exhaustion (Demerouti et al., 2001). However, this process was only partly supported in the current manager study. The results of path analysis revealed that only the hindrance demands (role overload) were positively related to exhaustion to a statistically significant degree whereas no job challenge indicators were showed to be significant predictors of exhaustion. From a statistical perspective, the rejection of the challenges-to-exhaustion relationship may be explained by the inadequate statistical power due to the small sample size of the line manager data (N = 94) and the large number of predictors (24 independent variables) involved.

The finding that role overload is a significant predictor of exhaustion is in agreement with the literature. For example, Koukoulaki (2014) argued that the primary mechanism accounting for the adverse health effects of lean production is work intensification, which in turn leads to increased levels of stress and exhaustion. Similarly, Anderson-Connolly et al. (2002) submitted that increased work intensity is the most detrimental aspect of lean production that produces poor health outcomes. Regarding the non-significant relationship between challenge demands (job complexity and problem-solving demands) and exhaustion, one plausible explanation is that the challenge demands faced by line managers in the company were not extreme enough to be harmful to individuals. Another possibility may be that the negative health impact of problem-solving demands and job complexity was reduced due to the substantial amount of technical training provided to these line managers. During the interviews with line managers prior to survey distribution, they reported high levels of involvement in technical training on a regular basis. These training activities may have helped them successfully solve production problems and reduce job complexity.

The current study also found that the cross-links between all forms of job resources and exhaustion were non-significant. Previous research has produced similar findings. For example, by surveying 1,636 hospital nurses in Canada, Jourdain and Chenevert (2010) found that seven out of eight measured job resources (including decision-making authority, supervisor support, colleague support, recognition by physicians, recognition by patients, competence and impact) were unrelated to exhaustion. A possible reason is that people's perceptions of exhaustion are more sensitive to harmful work characteristics (i.e. job demands) that cost them energy than to beneficial work characteristics (i.e. job resources) that fulfil their needs. The rationale for this derives from conservation of resources theory (Hobfoll, 2001). According to the theory, people have the tendency to protect themselves from resources loss and are more sensitive to work conditions that bring about resource losses than those that lead to resource gains. This is because job demands cause resource losses that are perceived by employees as important. In contrast, inadequate job resources only reduce the probability of enlarging their pool of existing resources and thus may be evaluated by workers as less threatening.

7.2.3. Validating the Interactions among Job Resources, Job Challenges and Job Hindrances

The survey results found that none of the sixteen job resource-job demand interactions were statistically significant. Therefore, the present study provided no support for the postulated moderation effects among job resources, challenges and hindrances. This conclusion provides further evidence for Schaufeli and Taris's (2014) argument that empirical studies rarely substantiate this interaction effect (see, for example, Bakker, Demerouti & Euwema, 2005; Bakker, Demerouti & Verbeke, 2004; Bakker, Demerouti, Taris, Schaufeli & Schreurs, 2003). As an illustration, in a survey of 146 Dutch employees from various industries, Bakker et al. (2004) found no support for the interaction hypothesis that job resources buffer the health impairment process. Similarly, empirical studies testing the interaction hypotheses proposed by Karasek's (1979) job demands-control model and the extended demand-control-support model (Karasek & Theorell, 1990) have also failed to yield significant results (e.g. De Jonge & Kompier, 1997; Van der Doef & Maes, 1999). On the basis of this evidence, Taris and Schaufeli (2016) predicted that the effects of resources/demands interaction terms on wellbeing-related outcomes are either sample-specific or dependent on other variables.

Another plausible reason accounting for the rejection of all of the interaction hypotheses is the smallness of the current line manager dataset (N = 94). Green (1991) provided a rough guidance for the minimum acceptable sample size in multiple regression: 50+8k, where k is the number of predictors. Given the fact that there are 24 predictors (including the interaction terms) in the current study, the minimal required sample size should be 242 cases according to Green's (1991) rule. This suggests that the small sample size of the current manager data is likely to yield unstable results.

7.3. Part Three: Comparing Findings between the Worker Data and the Line Manager Data

I will start by considering the seven most important common findings from both manager and worker surveys. First, the motivational and health-impairing processes of the JD-R model have been confirmed in both groups. This finding lends strong support to Schaufeli and Bakker's (2004) argument that job resources are the primary drivers of engagement whereas job demands are the main predictors of exhaustion. Second, the breakdown of job demands into hindrances and challenges is shown in both occupational groups to be necessary for better understanding the cross-links between job demands and work engagement. Results from both surveys indicated that challenge demands (measured by problem-solving demands in the worker survey and job complexity in the line manager survey) are positively related to engagement whereas hindrance demands (measured by role overload in both surveys) are negatively related to engagement. This is consistent with previous empirical studies (see, for example, Bakker & Sanz-Vergel, 2013; Van den Broeck et al., 2010; Tadic, Bakker & Oerlemans, 2015).

Third, the current survey data from both work groups found no statistically significant associations between challenge demands and exhaustion (H 2). This supports Schaufeli and Taris's (2014) redefinition of job resources to incorporate challenge demands. According to this line of thought, job challenges are valued by people as positive job characteristics that are instrumental in attaining work goals, reducing hindrance demands and promoting personal growth and development (Schaufeli & Taris, 2014). The practical implication of these findings is that not all job demands associated with lean production should be viewed as damaging and energy-depleting. Instead, only the hindrance demands (e.g. role overload and role conflict) that are negatively valued by workers as physiological and psychological costs should be managed more effectively. In contrast, challenge demands (e.g. problem-solving demands and job complexity) have motivational properties and therefore should be encouraged.

Fourth, hindrance demands (indicated by role overload) were identified from both surveys as the only significant predictor of exhaustion. This is congruent with Koukoulaki's (2014) proposition that the primary channel linking lean implementation to negative wellbeing outcomes is the intensification of work. Working mainly through increased levels of work intensity, stress and strain, role overload gives rise to deteriorated wellbeing outcomes for both work groups in the current study. This work-intensifying property appears to support Parker and Slaughter's (1988) definition of lean production as 'management by stress'. This outcome was also supported by the qualitative data from the managerial and non-managerial interviewees, who consistently reported that they had to attend more meetings, work overtime and pick up the work of other colleagues since the introduction of lean production.

The fifth common finding derived from both occupational groups is the non-significant cross-link between job resources and exhaustion. Hobfoll's (1989) conservation of resource theory offers an explanation. According to the theory, people weigh reward and punishment differently and in such a way that resource loss (i.e. job demands) is perceived as significantly more salient than resource gain. That is to say, given the same amounts of resource loss and gain, resource loss will have greater detrimental effects on employee wellbeing. This argument explains why providing workers with job resources may not necessarily contribute to reduced exhaustion, which is more responsive to job demands (i.e. resource loss).

Sixth, in testing the interaction effects, both managerial and non-managerial data have unanimously rejected two of the four hypotheses. Both of them involved hindrance demands: lean job resources alleviate the positive effect of lean job hindrances on exhaustion (H 8) and lean job resources boost work engagement particularly at the presence of high job hindrances (H 10). A number of possible explanations for these results can be offered. These findings may reflect the reality that the interaction effects between job resources and job demands are difficult to detect (Taris, 2006). Alternatively, the disconfirmation of these interaction effects could be attributed to the mismatch between the type of job resources and the type of job demands measured in the current study. As suggested by the triple match principle (De Jonge & Dormann, 2003), only when job demands, job resources and wellbeing indicators come from the same domain, can the interaction effects be detected. However, in the current study, composite resources were adopted. This measurement approach may have blurred the differing effects of each resource component from distinct domains. A final plausible reason for rejecting the above two interaction hypotheses in both data samples is that the joint effects of resources and demands on wellbeing may take more complicated forms such as three-way interaction (i.e. moderated moderation). Given the lack of evidence in the literature for the two-way interaction, I believe that future research should test the three-way interaction among job resources, job demands and personal resources in analyses of employee wellbeing. Personal resources are defined as 'positive self-evaluations that are linked to resiliency and refer to individuals' sense of their ability to control and impact upon their environment successfully' (Xanthopoulou, Bakker, Demerouti & Schaufeli, 2009, p. 236). According to Schaufeli & Taris (2014), personal resources closely resemble job resources because they also facilitate employees to accomplish work goals, keep them from threats and the consequent physiological and psychological costs, and promote personal growth and development. Previous studies have found that personal resources function as a second moderator moderating the relationship between the demands x resources interaction terms and wellbeing outcomes (e.g. Fernet, Guay & Senecal, 2004; Meier, Semmer, Elfering & Jacobshagen, 2008). As an illustration, Meier et al. (2008) surveyed 96 service employees in a Swiss logistic company to investigate the existence of the three-way interaction among job resources (i.e. job control), job demands (e.g. time pressure and performance constraints) and personal resources (including locus of control and self-efficacy) in the prediction of wellbeing (measured by affective strain and musculoskeletal pain). As hypothesized, the hierarchical regression results supported that job control buffered the impact of job demands on negative health outcomes only for employees with an internal locus of control. For others with an external locus of control, job control led to worsened wellbeing as job demands increased. Similarly, when self-efficacy served as the indicator of personal resources, Meier et al. (2008) found that the corresponding three-way interaction was also significant in predicting employee wellbeing.

7.4. Part Four: Contrasting Findings between the Worker Data and the Line Manager Data

Significant contrasts of findings were identified regarding H 7 (i.e. lean resources buffer the positive effect of lean challenges on exhaustion) and H 9 (i.e. lean job challenges moderate the positive effect of lean job resources on engagement). Both of these hypotheses were supported in the worker data but rejected in the line manager data. A possible explanation for this is the smallness of the line manager sample (N = 94), which produces less accurate statistical estimates (e.g. standard errors and confidence intervals), thereby reducing the possibility of detecting moderation effects. This indicates a logical next step for future research to survey a larger group of line managers so that the statistical power of detecting a genuine moderation effect can be increased.

7.5. Part Five: Strengths of the Study

The primary strengths of this study are four-fold. First, the study adopted a relatively uncommon, non-Western research context. The selection of a Chinese sample is important because it reduced the research gap that prior studies examining the impact of lean implementation on Chinese workers' wellbeing are extremely rare. Second, the current survey findings from the worker group have been cross-validated using an independent sample (N =

238). This approach is significant because it considerably strengthens the validity and reliability of the research findings. To my knowledge, no existing studies investigating the human implications of lean production have managed to cross-validate their results.

Third, the sample population in the present study is comprehensive, including all of the actors (managerial and non-managerial employees) involved in the operationalisation of lean practices. As discussed in chapter two, the literature on the lean production-to-wellbeing relationship has been dominated by a front-line worker's perspective. To date, no quantitative research has examined and shed light on the impact of lean implementation on Chinese line managers. To overcome this methodological limitation, this study embraced all actors' perspectives, thereby deepening our understanding of the human consequences under lean settings.

Fourth, the high level of response rates for both front-line workers (82 per cent) and line managers (91 per cent) not only adequately minimized the possibility of participation bias, but also increased the generalisability of the survey findings.

7.6. Part Six: Limitations of the Study and Directions for Future Research

The present study has six limitations. First, because this study is cross-sectional in nature, no causal interpretation of the empirical findings can be made. A logical next step is to test the current hypothesized model using panel data. Adopting a longitudinal research design is also useful for detecting potential reciprocal causation in the JD-R model. Previous studies (e.g. Hakanen, Perhoniemi & Toppinen-Tanne, 2008; Schaufeli, Bakker & van Rhenen, 2009) have demonstrated the existence of gain cycles in which job resources and work engagement mutually enhance each other. This reciprocal relationship suggests the dynamic nature of the motivational process in the JD-R model. Only assuming unidirectional causal relationships among lean resources, lean demands and employee wellbeing is too simplistic. Therefore, future research should dedicate more efforts to explore the dynamic relationships among the constructs in the JD-R model.

Second, the JD-R model at hand is a descriptive model of employee wellbeing that only specifies direct relationships between classes of variables but offers little psychological explanation on the mediation mechanisms involved (Schaufeli & Tari, 2014). To strengthen the explanatory power of the model, I believe that the incorporation of mediating hypotheses around the intermediate links between job demands/resources and wellbeing outcomes would be very useful to deepen our understanding of the theoretical mechanisms. For example, in Hu, Schaufeli and Taris's (2013) survey-based study of 625 Chinese labour workers and 1,381 nurses, the perception of equity was found to be a significant mediator transmitting the effects of job demands and job resources on employee wellbeing. Other theoretical frameworks that might also serve the mediator role include the effort-reward imbalance model (Siegrist, 1996) and the broaden-and-build theory (Fredrickson, 2001).

Third, only two-way interactions were examined in the current study. However, the literature has indicated that more complicated forms of interaction (e.g. three-way interactions) are likely to be in play. For example, personal resources (such as positive self-appraisals associated with resiliency and locus of control) (Xanthopoulou et al., 2009) were shown to function as another moderator influencing the joint effect between job demands and job resources in the prediction of employee outcomes (Meier et al., 2008). Therefore, it would be useful for future research to investigate the possibility of three-way interactions among job resources, job demands and other forms of personal resources.

Fourth, deficiencies stemming from the nature of a self-report questionnaire also apply in this study. Self-completion questionnaires offer no immediate clarification to participants on survey questions susceptible to misunderstanding. This could result in participants understanding questions incorrectly or increasing the tendency to disengage from the survey. To overcome this limitation, future research should collect objective data for measuring employee wellbeing, such as company records on rates of sickness absence and employee accidents.

The fifth research limitation is the single-case-study nature of the study. Because only one manufacturing company has been surveyed, the generalisability of research findings may be limited. However, this possibility is significantly reduced in the current study due to the successful cross-validation test using a second independent sample. I suggest future research to validate the current findings using data from companies in other industries with varying levels of lean implementation.

The last limitation of the study lies in the fact that the worker data might contain a cluster structure because workers are embedded in their respective work teams. As a result, questionnaire responses from one employee may be correlated with the responses from another employee within the same team. This implies that some of the observations in the worker sample may be non-independent of each other. In order to control for the nested nature of the data, multilevel-analysis techniques should be applied. However, this is not possible in the current study because of the anonymous nature of the survey, which contains no information about group membership.

7.7. Part Seven: Implications for Theory and Practice

7.7.1. Overview of the Theoretical Implications

The current study has a number of significant implications for theory. First, to the best of my knowledge, this study is the first of its kind in the Chinese context where the experiences and perceptions of lean implementation from the perspectives of both line managers and front-line workers are presented. Therefore, it adds unique China-specific findings to a body of similar international literature which has attempted to understand the lean manufacturing-to-wellbeing relationship in a particular context. Second, the present research findings confirm the applicability of the JD-R model in lean settings, thereby adding empirical support to the validity of the JD-R theory.

Third, this study contributes to the debate in the literature on the lean production-to-wellbeing relationship. The finding that there are both health-impairing and motivational job attributes under lean settings suggests that the overall impact of lean implementation on wellbeing is likely to depend on the specific lean practices applied on the shop floor and the implementation strategy adopted by management. If this argument holds, it is then reasonable to question previous studies that reported either uniformly positive (e.g. Womack et al., 1990) or uniformly negative results (e.g. Babson, 1993; Turnbull, 1988) in terms of the human consequences of lean production. The analyses conducted in these studies are largely one-sided, exclusively focused on either the motivational job characteristics (job resources) or detrimental job characteristics (job demands) in lean settings. What is left unexamined in these studies is the overall way in which lean production is implemented. This omission is important because, according to the findings in this study, different approaches to lean implementation determine the quality and quantity of job resources and demands, which in turn lead to distinct effects on employee wellbeing.

Identifying task interdependence as a neutral job characteristic that neither promotes nor jeopardizes wellbeing directly is the fourth theoretical implication. This finding is on the one hand in agreement with Sprigg et al.'s (2000) contingency approach to understanding the task interdependence-to-wellbeing relationship. On the other, it refutes the proposition in the JD-R model that all of the job characteristics can be classified as either job resources or job demands. The current study demonstrated that there should be a third group of job characteristics such as task interdependence that, when examined in isolation, are unrelated to employee wellbeing. Their effects on wellbeing depend on the extent to which they fit with other job characteristics in the company.

A fifth theoretical implication of the study is that not all job demands in the JD-R model function equally and therefore a redefinition of job demands is needed to differentiate between job challenges and job hindrances (Cullinane et al., 2013; Schaufeli & Taris, 2014). This conclusion derives from the finding that challenge demands (e.g. problem-solving demands) positively predict engagement and hindrance demands (e.g. role overload) solely determine exhaustion. This implication is significant because it helps us understand the contradictory evidence in the literature that the relationship between job demands and engagement is sometimes positive, but becomes negative at other times.

Sixth, all of the translated versions of measurement scales used in the current study have been cross-validated using Chinese data. This process strengthens the reliability and validity of the modified factorial structures of the scales for measuring lean-specific job characteristics. Future lean production research to be conducted in China can benefit from this by using the same measuring scales as validated in the present study. In doing so, contrasts and comparisons of findings derived from different research become meaningful.

Last but not the least, the present study illustrates the impact of organisational context (in this case, lean production) on determining the most important work characteristics, which further affect employee wellbeing. This empirical fact suggests that, for occupational health-related studies, the context-specific model of job stress should be developed so that it can accurately fit the particular work setting under investigation. This statement was echoed by Cullinane et al. (2013), who argued that the establishment of a contingent model of job stress is necessary, not only for studies under lean settings, but also for other research undertakings in different organisational contexts.

The importance of considering the particular organisational context in occupational health research also implies that the JD-R model is the most appropriate job stress model as compared to two other early models, namely the job demand-control model (JDC; Karasek & Theorell, 1990) and the job characteristics model (JCM; Hackman & Oldham, 1976, 1980). One of the primary deficiencies of the two models is their limited character. That is, both models have only specified a limited number of variables that are expected to predict job stress regardless of the working context. This is a serious drawback because they do not take into account the fact that the nature of jobs is ever-changing (Bakker & Demerouti, 2014). To elaborate, the fundamental proposition of the JDC model is that job demands give rise to work-related stress when job autonomy falls short. However, the model did not explain why job autonomy is the most significant resource for employees across occupations. It is highly likely that for different work groups, different job resources will predominate (Bakker & Demerouti, 2007). This raises the question regarding the universal applicability of the JDC model in all work environments. Likewise, the JCM is solely focused on five particular work characteristics: skill variety, feedback, job autonomy, task significance and task identity. Although it is acknowledged that these job features are important resources, I believe there are other forms of job resources that can be equally valuable as those five mentioned in the JCM. For example, O'Brien (1983) indicated that skill utilisation is a much stronger predictor of wellbeing than skill variety. Likewise, the current study has shown that employee participation in decision-making is an important motivator for workers under lean settings.

Unlike these two models with a restricted nature, the JD-R model is highly flexible because it does not constrain itself to specific forms of job resources and job demands. Instead, the model proposes that any demand and any resource can impact on employee wellbeing. The coverage of the JD-R model is much wider than that of the JCM and the JDC model because it takes into account the great variability of job characteristics across occupations by including all possible job demands and job resources. Because of its flexibility, the JD-R model can be tailored to adapt to any work environment. Therefore, I suggest that researchers in human resource management should consider adopting the JD-R model in their studies of employee outcomes.

7.7.2. Practical Implications

The findings of the current study also have important practical implications because they can be used as a general guidance for employers to develop a health-protecting lean implementation strategy. The first practical implication of the study to note lies in its demonstration of how the JD-R model offers value to management as a diagnostic tool to examine the impacts of production systems and models of HRM on employee wellbeing (Bakker, Oerlemans & Ten Brummelhuis, 2013; Huo & Boxall, 2017). Building from a qualitative data-gathering phase to identify specific demands and resources, the JD-R model can provide a quantitative testing of important propositions about the ways in which the demands of lean production and the resources provided affect employee wellbeing both independently and jointly.

As was shown in the study, employee wellbeing results from the balance between beneficial (resources) and detrimental (demands) job characteristics. From a practical point of view, this finding suggests that companies should design their lean systems from a configural perspective in order to protect employees from lean-related threats and the associated physiological and psychological costs. As noted by de Treville and Antonakis (2006), adopting configural thinking is important because workers on the shop floor do not interpret each individual lean practice independent of other practices. Instead, they perceive the joint effects of all of the practices operating concurrently. Longoni et al.'s (2013) interview-based study has shown that a configuration of lean-specific practices is more significant than are the independent main effects.

In line with configuration thinking, it is proposed that employers should choose to apply a set of complementary lean practices in order to strike a balance between job resources and job demands. In doing so, job demands can be offset by corresponding job resources. For example, as is widely believed among researchers, lean production is inherently an environment of low job autonomy at the individual level (i.e. timing and work method autonomy) primarily because of work standardisation. However, according to JD-R thinking, the dearth of this form of job resources is not necessarily detrimental for employee wellbeing if other beneficial work characteristics are made available that compensate for and overcome the shortage of individual-level job control. As identified in the current study, employee involvement in decision-making is one of the job resources that can remedy the inherent constraints of method and timing autonomy under lean contexts. The reasoning is that employee involvement (e.g. continuous improvement programs and quality circle meetings) enables employees to have responsibility and decision-making authority at a higher organisational level. Under such circumstances, employees are more likely to have genuine possibilities for influence and learning, which may compensate for the lack of individual-level job autonomy (Boxall & Winterton, 2015).

Another point of learning for business practitioners is that excessive leanness should be avoided in the implementation of lean production (de Treville & Antonakis, 2006) because it not only exacerbates job demands (mainly in the form of work intensification), but also increasingly reduces job resources. Two of the fundamental objectives of lean production are continuous improvement and waste elimination. This is usually achieved by continuously reducing job resources required for production (e.g. buffer stocks, manpower and idle time). This resource-cutting phenomenon has the potential to be never-ending because every improvement in production flow or reduction in waste leads to new goals of further resource reduction. Eventually, extreme leanness is likely to occur where employees are deprived of all forms of job resources. When this happens, worsened employee outcomes such as stress, exhaustion and work injuries may be expected (see for example, Fucini & Fucini, 1990; Graham, 1995; Rinehart et al., 1997). On the basis of these arguments, it is suggested that business practitioners should be cautious about their attempts of pursuing extreme leanness. Namely, management has to offer workers marginally more job resources than are required for production, if their wellbeing is to be safeguarded and enhanced. For example, when a company employs the lean practice of JIT inventory control, it is advisable to provide workers with a certain amount of buffer stocks, rather than a complete elimination. When this happens, the increased work intensity as a result of JIT can be counterbalanced by the provision of rest breaks and informal job control made available by the stockpiling of buffer inventory.

In accordance to the literature (Conti et al., 2006; Hasle, 2012; Koukoulaki, 2014), it was found in the current study that both beneficial (i.e. resources) and adverse (i.e. demands) effects on wellbeing are coexistent under lean settings. As a result, the question to be solved is how to reduce detrimental effects while at the same time promoting positive effects. Drawing on the present research findings, the answer to this question is that employers should not only offer sufficient lean job resources (e.g. training, line manager support and employee involvement in decision-making), but also minimize hindrance demands (e.g. role overload). This refutes Womack et al.'s (1990) claim that providing lean workers with slightly fewer resources than are needed in practice can motivate them for creative problem-solving. The current study found contradictory evidence that inadequate job resources disengage employees from their work. This evidence also emphasizes the importance of the provision of sufficient job resources for employee wellbeing. I believe that this is the most pressing issue to be resolved in lean settings. The reason is that, as noted in the literature (Anderson-Connolly et al., 2002; Conti et al., 2006; Koukoulaki, 2014), a number of job demands such as increased work intensity and lack of job autonomy are inherent in lean environments. Given that these job demands are inevitable for lean workers, the availability of directly-targeted job resources for coping becomes extremely critical to buffer their detrimental effects on employee health (Huo & Boxall, 2017). For example, this could include an assessment of the adequacy of staffing levels, the frequency and duration of rest breaks, and the residual level of buffer inventories.

Moreover, the current study showed that, bearing a strong analogy to job resources, job challenges are positively related to work engagement and unrelated to exhaustion. This finding offers support for the distinction between hindrance demands and challenge demands in predicting employee wellbeing. The practical implication is that not all job demands associated with lean production are detrimental and should be minimized. Instead, job demands of a challenging nature are helpful for attaining work goals, and stimulating personal growth and development. Apart from the motivational quality of job challenges in their own right, the present study confirmed that job challenges also serve as a moderator that boosts the positive effect of job resources on employee wellbeing. These results suggest that employers ought to provide workers with both resources and challenges simultaneously.

8. Chapter Eight: Conclusion

Drawing on the JD-R model as a diagnostic tool, this study investigated the effect of lean implementation on employee wellbeing in a Chinese manufacturer with extensive usage of lean production. Building from a qualitative data-gathering phase to identify company-specific demands and resources, quantitative data were collected using questionnaire surveys. Two sets of questionnaires were devised targeted at front-line workers (N = 371) and line managers (N = 94) respectively in the case company. The comprehensive coverage of the sample population in the current study is one of its original contributions to academic research.

8.1. Answer to the Research Question

The overall research question posed in the thesis was 'when does lean production enhance employee wellbeing?' Stemming from the current survey findings, my proposed answer is that: lean implementation promotes employee outcomes when management effectively distinguishes job challenges from job hindrances and provides sufficient, directly-targeted resources to each of these two types of demand. This conclusion is reached on the basis of the following key findings. Both worker and line manager data showed that resources such as relevant training, support from management and employee participation in decision-making, along with the challenges posed by problem-solving demands, can enhance employee work engagement in the context of lean production. In stark contrast, role overload functions as a hindrance demand and poses a threat to both workers and managers in terms of fostering greater exhaustion and jeopardizing work engagement. In addition, results from the worker data provided support for two interaction effects between job resources and challenge demands (i.e. the buffering effect of job resources on the challenges-to-exhaustion relationship and the coping effect of job challenges on the resources-to-engagement relationship). This highlights the importance of a careful matching of resources to the type of demand encountered by workers.

On the basis of the above-mentioned survey findings, I submit three strategies for practitioners to enhance employee wellbeing under lean production settings. First and foremost, employers should not only offer adequate job resources (e.g. competitive rewards, training, line manager support and employee involvement in decision-making) and foster job challenges (e.g. problem-solving demands), but also simultaneously minimize hindrance demands (e.g. role overload). In addition, when designing the lean production system, companies should choose to apply a set of complementary lean practices so as to accurately match job resources with the type of demand faced by the production workforce (e.g. JIT programs match up with the provision of buffer stocks and standardized work is implemented hand in hand with employee participation in decision-making). In doing so, job demands can be offset by directly-targeted job resources. Last but not the least, in the implementation of lean production, organisational leaders are advised to set an upper limit for the degree of leanness that the company attempts to achieve, rather than pursuing excessive leanness. Otherwise employees would be faced with endless job demands and increasingly deprived of job resources, thereby ultimately causing ill-being.

8.2. Overview of the Thesis Contribution

The current thesis has a number of original contributions to academic research regarding the impact of lean production on employee wellbeing. First, although the JD-R model has been recognised as one of the leading job stress models and widely applied in a variety of non-lean work settings, very little existing research has examined its applicability and usefulness in explaining both the beneficial and detrimental effects of lean implementation on employees. This thesis reduced this research gap by confirming that the JD-R model is a diagnostic tool to help us understand the mixed effects of lean implementation on employee outcomes. Applying the JD-R model in lean settings not only enables the identification of specific job resources, challenges and hindrances that are characteristic of the given lean production context, it also clarifies the motivational and health-impairing processes through which each of these lean job attributes affects wellbeing. This finding offers a new way of lean implementation in which the health-impairing elements of lean can be distinguished from the motivational elements, whereby counteracting the detrimental effect of job demands with directly-targeted job resources becomes possible. When this happens, a win/win outcome is more likely to be realized where lean implementation promotes both organisational performance and employee wellbeing.

The current thesis also provides an explanation for the contradictory findings of prior research, which has identified both positive and negative human consequences of lean production. The likely reason is that different studies have focused on different attributes of lean production. It is often the case that the analyses conducted in prior research are one-sided, exclusively focused on either the motivational job characteristics (resources) or detrimental job characteristics (demands) in lean settings. To elaborate, if the lean practices under examination are positively evaluated by employees as job resources or challenges (e.g. extensive training and employee participation in decision-making), the study (e.g. Womack et al., 1990) is likely to reach a positive conclusion on the lean production-to-wellbeing relationship. If the lean techniques under investigation are negatively valued by employees as job hindrances (e.g. JIT production and waste elimination), the study (e.g. Parker, 2003) is likely to find a negative effect of lean implementation on wellbeing. A particularly neglected subject in these studies is the overall way in which lean production is implemented. This subject is important because, as shown in the current findings, different approaches to implementing lean practices determine the variability of the quality and quantity of job resources and demands, which in turn give rise to distinct effects on employee wellbeing.

Last but not the least, the interaction effects between lean job resources and job challenges with regard to both exhaustion and engagement have all been confirmed. This contributes to the literature by suggesting that job demands are not solely damaging and health-impairing. Instead, job demands of a more challenging nature can interact with job resources, thereby boosting the positive effect of job resources on employee outcomes. On the basis of this finding, I argue that future research should move away from the expectation that the effect of lean production on employee wellbeing can be either uniformly positive or consistently negative. Instead, the best way to address this question is to first distinguish resources and challenges from hindrances in the particular lean work context and then provide adequate, directly-targeted resources to cope with the particular job hindrance. When this happens, workers can perceive a balance between these two opposite sets of job characteristics. This balance ultimately leads to a win/win lean work environment which is mutually beneficial for both organisational performance and employee wellbeing.

Appendices:

Appendix A: Interview Questions

Questions for line managers:

1. Please tell me about the implementation of lean production in the company. When was it introduced and why? What have been the outcomes or results so far?
2. Which particular lean practices have been implemented? Why and how? What is the importance of each practice?
3. What changes have been made in how work is organised and people are managed? Why and how?
4. How have lean practices changed your job? Which ones have most affected you? How do you feel about these changes? Have they been of benefit? If so, how? Or have they been problematic? If so, how?
5. How have lean practices changed your workers' jobs? Which ones have most affected them? How do you think they feel about these changes? Have they been of benefit? If so, how? Or have they proved problematic for them? If so, how?
6. Where is lean production heading now in the company? Are there any aspects of lean production in your company that could be improved? Why so and how would you change them?

Questions for front-line workers

1. Please tell me what you did in your job before lean production was implemented.
2. What are your job responsibilities now in lean production? Has anything changed? If so, what?
3. Have you been required to learn any new skills? If so, what? How have you learnt these new skills?
4. How do you feel about the way your job has changed? Has it benefited you or made your job more stressful? Please explain.
5. Are there any aspects of lean production in your company that you think need to be improved? Why so and how could they be changed?

Questions for HR professionals

1. Can you please explain what role the HR department has played in the design and implementation of lean production?

2. Have there been any the challenges or problems in implementing lean production that you are aware of? If so, what are they and why have they been an issue? What has been done about them? What role have HR staff played in addressing any issues?
3. Can you see ways in which lean production can be improved? What are they and what should be done about them?

Appendix B: The Front-Line Worker Experience of Lean Production

The objective of the current study is to investigate the impact of lean production on employee wellbeing. I would deeply appreciate your participation in this study. The following questionnaire should take approximately fifteen minutes of your time to complete.

I am asking you to complete all questions and to answer them according to your own personal opinion. Confidentiality and anonymity of your answers are guaranteed.

Thank you in advance for your participation.

Section 1

The scale for vigour:

Please read each statement below and rate (tick box) how frequently you feel this way at work.

How frequently do you feel with the following?	never	almost never (a few times a year or less)	rarely (once a month or less)	sometimes (a few times a month)	often (once a week)	very often (a few times a week)	always (everyday)
1. When I get up in the morning, I feel like going to work.							
2. At my work, I feel bursting with energy.							
3. At my job I feel strong and vigorous.							

The scale for dedication:

Please read each statement below and rate (tick box) how frequently you feel this way at work.

How frequently do you feel with the following?	never	almost never (a few times a year or less)	rarely (once a month or less)	sometimes (a few times a month)	often (once a week)	very often (a few times a week)	always (everyday)
1. My job inspires me.							
2. I am enthusiastic about my job.							
3. I am proud of the work that I do.							

The scale for exhaustion:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. After work I usually feel worn out and weary.							
2. There are days when I feel tired before I arrive at work.							
3. After work, I tend to need more time than in the past in order to relax and feel better.							
4. During my work, I often feel emotionally drained.							

Section 2

The scale for lean production training:

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. The company provides me with adequate technical training in lean production.							
2. The company provides me with adequate team skills training (e.g. communication and interpersonal skills).							
3. The company provides me with adequate quality training.							

The scale for line manager support:

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. My manager really cares about my well-being.							
2. My manager considers my goals and values (Dropped)							
3. My manager cares about my opinions.							
4. My manager is willing to help if I need a special favour.							
5. Help is available from my manager when I have a problem.							
6. My manager would forgive an honest mistake on my part.							

The scale for employee participation:

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. I am encouraged to suggest ideas for improving standard operating procedures.							
2. My manager actively seeks my ideas for improving working conditions.							
3. My manager welcomes my ideas when I speak up in quality circle meetings.							
4. My manager actively seeks my opinion when we encounter a production problem.							

The scale for task interdependence:

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. I work closely with others in doing my work.							
2. I frequently must coordinate my efforts with others.							
3. My own performance is dependent on receiving accurate information from others. (Dropped)							
4. The way I perform my job has a significant impact on others. (Dropped)							
5. My work requires me to consult with others fairly frequently.							

The scale for role overload:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. It often seems like I have too much work for one person to do.							
2. The performance standards on my job are too high.							
3. I have too much work to do to do everything well.							
4. I never seem to have enough time to get everything done.							

The scale for problem-solving demands:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. I am regularly required to deal with problems which are difficult to solve.							
2. I regularly have to solve problems which have no obvious correct answer. (Dropped)							
3. I regularly have to use my production knowledge to help prevent problems arising in my job.							
4. The problems I deal with regularly require a thorough knowledge of production in my area.							
5. I regularly encounter problems in my job that I have not met before.							

Section 3

1. Gender: ☐ Male ☐ Female
2. Age: ________
3. Education level:

   ☐Junior high school ☐Senior high school ☐Vocational Training

   ☐Bachelor degree ☐Master’s degree

   Other (please specify) ____________
4. How many years have you worked with the company? _______

→ END OF QUESTIONNAIRE

Appendix C: The Line Manager Experience of Lean Production

The objective of the current study is to investigate the impact of lean production on line manager wellbeing. I would deeply appreciate your participation in this study. The following questionnaire should take approximately ten minutes of your time to complete.

I am asking you to complete all questions and to answer them according to your own personal opinion. Confidentiality and anonymity of your answers are guaranteed.

Thank you in advance for your participation.

Section 1

The scale for vigour:

Please read each statement below and rate (tick box) how frequently you feel this way at work.

How frequently do you feel with the following?	never	almost never (a few times a year or less)	rarely (once a month or less)	sometimes (a few times a month)	often (once a week)	very often (a few times a week)	always (everyday)
1. When I get up in the morning, I feel like going to work.							
2. At my work, I feel bursting with energy.							
3. At my job I feel strong and vigorous.							

The scale for dedication:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

How frequently do you feel with the following?	never	almost never (a few times a year or less)	rarely (once a month or less)	sometimes (a few times a month)	often (once a week)	very often (a few times a week)	always (everyday)
1. My job inspires me.							
2. I am enthusiastic about my job.							
3. I am proud of the work that I do.							

The scale for exhaustion:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. After work I usually feel worn out and weary.							
2. There are days when I feel tired before I arrive at work.							
3. After work, I tend to need more time than in the past in order to relax and feel better.							
4. During my work, I often feel emotionally drained.							

Section 2

The scale for lean production training:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. The company provides me with adequate technical training in lean production.							
2. The company provides me with adequate team skills training (e.g. communication and interpersonal skills).							
3. The company provides me with adequate quality training.							

The scale for top management support:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. Top management has taken the responsibility for initiating and maintaining lean production goals and culture.							
2. Top management's vision and commitment to lean production is continually communicated to all employees.							
3. The policy and strategy of our organisation are based on the concept of lean production.							
4. Top management has devised credible reward systems that recognise employees and managers for their lean production achievements.							
5. Necessary policy changes have been made to encourage employees' participation and involvement in lean production.							
6. Top management is involved in reviewing progress towards lean production.							
7. Top management spends a significant proportion of time on lean production-related issues.							

The scale for decision-making autonomy:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. The job gives me a chance to use my personal initiative or judgement in carrying out work.							
2. The job allows me to make a lot of decisions on my own.							
3. The job provides me with significant autonomy in making decisions.							

The scale for work method autonomy:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. The job allows me to make decisions about what methods I use to complete my work.							
2. The job gives me considerable opportunity for independence and freedom in how I do the work.							
3. The job allows me to decide on my own how to go about doing my work.							

The scale for task interdependence:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. I work closely with others in doing my work.							
2. I frequently must coordinate my efforts with others.							
3. My own performance is dependent on receiving accurate information from others.							
4. The way I perform my job has a significant impact on others.							
5. My work requires me to consult with others fairly frequently.							

The scale for role overload:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. It often seems like I have too much work for one person to do.							
2. The performance standards on my job are too high.							
3. I have too much work to do to do everything well.							
4. I never seem to have enough time to get everything done.							

The scale for problem-solving demands:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. I am regularly required to deal with problems which are difficult to solve.							
2. I regularly have to solve problems which have no obvious correct answer.							
3. I regularly have to use my production knowledge to help prevent problems arising in my job.							
4. The problems I deal with regularly require a thorough knowledge of production in my area.							
5. I regularly encounter problems in my job that I have not met before.							

The scale for job complexity:

Please read each statement below and rate (tick box) how strongly you agree or disagree with it.

To what extent do you agree or disagree with the following statements?	strongly disagree	disagree	slightly disagree	neither disagree nor agree	slightly agree	agree	strongly agree
1. The job requires that I only do one task or activity at a time.							
2. The tasks on the job are simple and uncomplicated.							
3. The job comprises relatively uncomplicated tasks.							
4. The job involves performing relatively simple tasks.							

Section 3

1. Gender: ☐ Male ☐ Female

2. Age: _________

3. Education level:

   ☐ Junior high school ☐ Senior high school ☐ Vocational Training

   ☐ Bachelor degree ☐ Master's degree

   Other (please specify) _____________

4. How many years have you worked with the company? ________________

→ END OF QUESTIONNAIRE

Appendix D: Participant Information Sheet – General Manager

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Department of Management and International Business
Level 4 Owen Glen G Building
Phone: +64 9 3737599
The University of Auckland
Private Bag 92019
Auckland, New Zealand

Participant Information Sheet – General Manager

<u>Project title:</u> When does Lean Production Enhance Employee Wellbeing?

I am writing to ask if you would kindly allow your organisation to participate in my research. My name is Menglong Huo, a doctoral student supervised by Prof. Peter Boxall at the University of Auckland's Department of Management and International Business. By surveying front-line workers and line managers in your organisation, my research aims to investigate the way lean production can be implemented to the benefit of employee wellbeing.

What I am asking is your permission for your secretarial assistant to (1) select 10 front-line workers, 9 line managers and 2 HR professionals for 40-minute interviews about their experiences of lean production practices; (2) forward a 10 to 15 minute paper survey to the entire population of your front-line workers and line managers regarding their perceived wellbeing effects of lean production implemented in your organisation; (3) forward the identical survey to the entire population of your front-line workers and line managers 6 months later for the second wave of my data collection. If you are happy for me to do so, all you need do is to sign and return the attached form, and forward my invitation letter to your secretarial assistant so that he/she can distribute the letter to the relevant employees. Their participation is entirely voluntary.

The information derived from interviews will be captured only by note-taking because it is mainly used to guide the design of questionnaire survey in the next stage. In addition, I will not collect the organisation's or participants' names on the surveys, thus, the survey responses are anonymous and not being linked to any particular participant. Given the anonymous nature of the survey, participants will be unable to withdraw data after returning the questionnaire. However, participants have the right to withdraw from the research without giving a reason before their submission of the completed survey to me.

The data will be used to write my doctoral dissertation and academic journal articles. It will be stored on a designated university computer for 6 years and then destroyed. Finally, I seek your assurance that participation or non-participation will not affect the participants' employment.

Thank you very much in advance for your help. Upon completing my dissertation, I will send to you a summary of my findings. If you have any questions about the project, please contact any of the following:

Researcher: Menglong Huo, Department of Management and International Business, The University of Auckland. Ph: +64 9 3737599 extn 73359, Email:m.huo@auckland.ac.nz
Supervisor: Professor Peter Boxall, Department of Management and International Business, The University of Auckland. Ph: +64 9 9237355, Email: p.boxall@auckland.ac.nz
Local contact: Mr. Xiguang Lu, Head of Lean Production Department, Enric Group Corporation. Ph: +86 15373963055, Email: luxiguang@enricgroup.com
Head of Department: Professor Nigel Haworth, Department of Management and International Business, The University of Auckland. Ph: +64 9 3737599 extn 85235, Email: n.haworth@auckland.ac.nz
For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag: 92019, Auckland 1142. Telephone: 09 373 7599 extn. 83711. Email: ro-ethics@auckland.ac.nz

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON…03/07/2015…… for (3) years, Reference Number…….015115……

Appendix E: Consent Form – General Manager

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau
Department of Management and International Business
Level 4 Owen Glen G Building
Phone: +64 9 3737599
The University of Auckland
Private Bag 92019
Auckland, New Zealand

Consent Form – General Manager

THIS FORM WILL BE HELD FOR A PERIOD OF 6 YEARS

Project title: When does Lean Production Enhance Employee Wellbeing?
Researcher: Menglong Huo

I have read the participant information sheet, have understood the nature of the research. I have had the opportunity to ask questions and have them answered to my satisfaction.

- I agree to my organisation taking part in this research.
- I consent to 21 of my employees being contacted and invited to complete a 40-minute interview. I understand that their participation is entirely voluntary and interview information will only be captured by note-taking.
- I consent to my line managers and front-line workers being contacted and invited to complete a 10-15 minute survey. I understand that their participation is entirely voluntary.
- I consent to my line managers and front-line workers being invited to complete the identical survey 6 months later after the first round of survey data collection.
- I understand that participants are unable to withdraw data from the research after returning the questionnaire due to the nature of the anonymous response.
- I understand that the surveys are anonymous because no identifying information, such as participant or organisation name, will be collected.
- I understand that data will be stored for 6 years and used to write the student's Doctoral dissertation and academic journal articles.
- I understand that if the results are published, participants' identity and any individual information they provide will remain anonymous.
- I give my assurance that the fact of my employees' participation or non-participation in this research will have no effect on their employment status.

- I wish/do not wish to receive a summary of findings.

If you wish to receive a summary of findings, please enter an email address here:

____

Name_______________________

Signature____________________ Date________________

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON…03/07/2015…… for (3) years, Reference Number…….015115……

Appendix F: Survey Participant Information Sheet – Line Managers

Department of Management and International Business
Level 4 Owen Glen G Building
Phone: +64 9 3737599
The University of Auckland
Private Bag 92019
Auckland, New Zealand

Survey Participant Information Sheet – Line Manager

Project title: When does Lean Production Enhance Employee Wellbeing?

This research is being conducted by Menglong Huo, a doctoral student supervised by Prof. Peter Boxall. The research is being undertaken as part of a doctoral thesis in the University of Auckland's Department of Management and International Business. By surveying the line manager occupational group in your company, the objective is to investigate the impact of lean production on their wellbeing and how to implement lean production to the benefit of their wellbeing.

I am asking line managers from your company to complete a 10-15 minute survey about their perception of lean production in relation to its impact on wellbeing. As the head in your department, you are invited to participate. You will be asked about your experiences of implementing lean production practices in your organisation. Participation is entirely voluntary, and no identifying information about you will be collected.

The survey responses are anonymous and not being linked to any particular participant. Because your name will not be on the survey, you will not be able to withdraw data after completing it. However, you have the right to withdraw from the research without giving a reason before your submission of the completed survey. The data will be used to write my doctoral dissertation and an academic journal article. It will be stored on a designated university computer for 6 years and securely destroyed at the end of this period.

Although your general manager forwarded my questionnaire survey to you, he will not know whether you participate or not. You are assured that the fact of your participation or non-participation in this research will have no effect on your employment status with your organisation.

Upon the research completion, if you would like to receive a summary of the research findings, you are welcome to contact me. Thank you very much for your help.

If you have any questions about the project, please contact any of the following:

Researcher: Menglong Huo, Department of Management and International Business, The University of Auckland. Ph: +64 9 3737599 extn 73359, Email: m.huo@auckland.ac.nz
Supervisor: Professor Peter Boxall, Department of Management and International Business, The University of Auckland. Ph: +64 9 9237355, Email: p.boxall@auckland.ac.nz
Local contact: Mr. Xiguang Lu, Head of Lean Production Department, Enric Group Corporation. Ph: +86 15373963055, Email: luxiguang@enricgroup.com
Head of Department: Professor Nigel Haworth, Department of Management and International Business, The University of Auckland. Ph: +64 9 3737599 extn 85235, Email: n.haworth@auckland.ac.nz

For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag: 92019, Auckland 1142. Telephone: 09 373 7599 extn. 83711.Email: ro-ethics@auckland.ac.nz

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON…03/07/2015…… for (3) years, Reference Number……015115…….

Appendix G: Survey Participant Information Sheet – Front-Line Employees

Department of Management and International Business
Level 4 Owen Glen G Building
Phone: +64 9 3737599
The University of Auckland
Private Bag 92019
Auckland, New Zealand

Survey Participant Information Sheet – Front-Line Employee

Project title: When does Lean Production Enhance Employee Wellbeing?

This research is being conducted by Menglong Huo, a doctoral student supervised by Prof. Peter Boxall. The research is being undertaken as part of a doctoral dissertation in the University of Auckland's Department of Management and International Business. By surveying the front line employee occupational group in your company, the objective is to investigate the effect of lean production on their wellbeing and how to implement lean production to the benefit of their wellbeing.

I am asking employees from your company to complete a 10-15 minute survey about their perception of lean production in relation to its impact on wellbeing. As an employee in your organisation, you are invited to participate. Participation involves completing a 10 to 15 minute survey. You will be asked about your experiences of implementing lean production practices in your organisation. Participation is entirely voluntary, and no identifying information about you will be collected.

The survey responses are anonymous and not being linked to any particular participant. Because your name will not be on the survey, you will not be able to withdraw data after completing it. However, you have the right to withdraw from the research without giving a reason before your submission of the completed survey. The data will be used to write my doctoral thesis and an academic journal article. It will be stored on a designated university computer for 6 years and securely destroyed at the end of this period.

Although your general manager forwarded my questionnaire to you, he will not know whether you participate or not. You are assured that the fact of your participation or non-participation in this research will have no effect on your employment status with your organisation.

Upon the research completion, if you would like to receive a summary of the research findings, you are welcome to contact me. Thank you very much for your help.

If you have any questions about the project, please contact any of the following:

Researcher: Menglong Huo, Department of Management and International Business, The University of Auckland. Ph: +64 9 3737599, extn. 73359, Email:m.huo@auckland.ac.nz
Supervisor: Professor Peter Boxall, Department of Management and International Business, The University of Auckland. Ph: +64 9 9237355, Email: p.boxall@auckland.ac.nz
Local contact: Mr. Xiguang Lu, Head of Lean Production Department, Enric Group Corporation. Ph: +86 15373963055, Email: luxiguang@enricgroup.com
Head of Department: Professor Nigel Haworth, Department of Management and International Business, The University of Auckland. Ph: +64 9 3737599 extn. 85235, Email: n.haworth@auckland.ac.nz
For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag: 92019, Auckland 1142. Telephone: 09 373 7599 extn. 83711. Email: ro-ethics@auckland.ac.nz

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON…03/07/2015…… for (3) years, Reference Number…….015115……

Appendix H: Interview Participant Information Sheet – Front-Line Employees

Department of Management and International Business
Level 4 Owen Glen G Building
Phone: +64 9 3737599
The University of Auckland
Private Bag 92019
Auckland, New Zealand

Interview Participant Information Sheet – Front-Line Employees

Project title: When does Lean Production Enhance Employee Wellbeing?

The research is being conducted by Menglong Huo, a doctoral student supervised by Prof. Peter Boxall. This research is being undertaken as part of a doctoral dissertation in the University of Auckland's Department of Management and International Business. By interviewing a small sample of employees in your organisation regarding their perceived job characteristics under lean production, the objective is to inform the design of a questionnaire survey examining the wellbeing effect of lean production.

As an employee in your organisation, you are invited to participate in a 40 minute interview regarding your perception of job characteristics under lean production. The interview will be conducted either in person or by phone call. The comments and information you provide in the interview will only be captured by note-taking and will not be disclosed to other people. These notes will be stored in the departmental repository on University of Auckland premises for up to six years after the completion of the doctoral dissertation. All of these notes will be destroyed using a shredder at the end of this period. The interview information will mainly be used to guide the design of a questionnaire survey that will be used in the next phase of data collection. Participation is entirely voluntary and you can withdraw from the interview at any stage without explanation.

Your general manager allows me to contact any of the relevant employees in your organisation, but has assured me that the fact of your participation or non-participation in this interview will have no effect on your employment status with your organisation. Although your general manager provided your contact details for me, he will not know whether you participate or not.

Upon the research completion, if you would like to receive a summary of the survey findings, you are welcome to contact me. Thank you very much for your help.

If you have any questions about the project, please contact any of the following:

Researcher: Menglong Huo, Department of Management and International Business, The University of Auckland. Ph: +64 9 3737599, extn. 73359, Email: m.huo@auckland.ac.nz
Supervisor: Professor Peter Boxall, Department of Management and International Business, The University of Auckland. Ph: +64 9 9237355, Email: p.boxall@auckland.ac.nz
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Head of Department: Professor Nigel Haworth, Department of Management and International Business, The University of Auckland. Ph: +64 9 3737599 extn. 85235, Email: n.haworth@auckland.ac.nz
For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag: 92019, Auckland 1142. Telephone: 09 373 7599 extn. 83711. Email: ro-ethics@auckland.ac.nz

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON…03/07/2015…… for (3) years, Reference Number…….015115…….

Appendix I: Interview Participant Information Sheet – Line Managers

Department of Management and International Business
Level 4 Owen Glen G Building
Phone: +64 9 3737599
The University of Auckland
Private Bag 92019
Auckland, New Zealand

Interview Participant Information Sheet – Line Managers

<u>Project title:</u> When does Lean Production Enhance Employee Wellbeing?

The research is being conducted by Menglong Huo, a doctoral student supervised by Prof. Peter Boxall. This research is being undertaken as part of a doctoral dissertation in the University of Auckland's Department of Management and International Business. By interviewing a small sample of line managers in your organisation regarding their perceived job characteristics under lean production, the objective is to inform the design of a questionnaire survey examining the wellbeing effect of lean production.

As a line manager in your organisation, you are invited to participate in a 40 minute interview regarding your perception of job characteristics under lean production. The interview will be conducted either in person or by phone call. The comments and information you provide in the interview will only be captured by note-taking and will not be disclosed to other people. These notes will be stored in the departmental repository on University of Auckland premises for up to six years after the completion of the doctoral dissertation. All of these notes will be destroyed using a shredder at the end of this period. The interview information will mainly be used to guide the design of a questionnaire survey that will be used in the next phase of data collection. Participation is entirely voluntary and you can withdraw from the interview at any stage without explanation.

Your general manager allows me to contact any of the relevant line managers in your organisation, but has assured me that the fact of your participation or non-participation in this interview will have no effect on your employment status with your organisation. Although your general manager provided your contact details for me, he will not know whether you participate or not.

Upon the research completion, if you would like to receive a summary of the survey findings, you are welcome to contact me. Thank you very much for your help.

If you have any questions about the project, please contact any of the following:

Researcher: Menglong Huo, Department of Management and International Business, The University of Auckland. Ph: +64 9 3737599 extn. 73359, Email: m.huo@auckland.ac.nz
Supervisor: Professor Peter Boxall, Department of Management and International Business, The University of Auckland. Ph: +64 9 9237355, Email: p.boxall@auckland.ac.nz
Local contact: Mr. Xiguang Lu, Head of Lean Production Department, Enric Group Corporation. Ph: +86 15373963055, Email: luxiguang@enricgroup.com
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For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag: 92019, Auckland 1142. Telephone: 09 373 7599 extn. 83711. Email: ro-ethics@auckland.ac.nz

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON…03/07/2015…… for (3) years, Reference Number…….015115…….

Appendix J: Interview Participant Information Sheet – Human Resource Professionals

Department of Management and International Business
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The University of Auckland
Private Bag 92019
Auckland, New Zealand

Interview Participant Information Sheet – Human Resource Professionals

Project title: When does Lean Production Enhance Employee Wellbeing?

The research is being conducted by Menglong Huo, a doctoral student supervised by Prof. Peter Boxall. This research is being undertaken as part of a doctoral dissertation in the University of Auckland's Department of Management and International Business. By interviewing two of HR professionals in your organisation regarding the implementation of HR practices to facilitate workers' adaptation to lean production, the objective is to inform the design of a questionnaire survey examining the wellbeing effect of lean production.

As an HR professional in your organisation, you are invited to participate in a 40 minute interview regarding your experiences of HR practices being used in your company to help with workers' adaptation to lean production. The interview will be conducted either in person or by phone call. The comments and information you provide in the interview will only be captured by note-taking and will not be disclosed to other people. These notes will be stored in the departmental repository on University of Auckland premises for up to six years after the completion of the doctoral dissertation. All of these notes will be destroyed using a shredder at the end of this period. The interview information will mainly be used to guide the design of a questionnaire survey that will be used in the next phase of data collection. Participation is entirely voluntary and you can withdraw from the interview at any stage without explanation.

Your general manager allows me to contact any of the relevant employees in your organisation, but has assured me that the fact of your participation or non-participation in this interview will have no effect on your employment status with your organisation. Although your general manager provided your contact details for me, he will not know whether you participate or not.

Upon the research completion, if you would like to receive a summary of the survey findings, you are welcome to contact me. Thank you very much for your help.

If you have any questions about the project, please contact any of the following:

Researcher: Menglong Huo, Department of Management and International Business, The University of Auckland. Ph: +64 9 3737599 extn. 73359, Email: m.huo@auckland.ac.nz
Supervisor: Professor Peter Boxall, Department of Management and International Business, The University of Auckland. Ph: +64 9 9237355, Email: p.boxall@auckland.ac.nz
Local contact: Mr. Xiguang Lu, Head of Lean Production Department, Enric Group Corporation. Ph: +86 15373963055, Email: luxiguang@enricgroup.com
Head of Department: Professor Nigel Haworth, Department of Management and International Business, The University of Auckland. Ph: +64 9 3737599 extn. 85235, Email: n.haworth@auckland.ac.nz
For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag: 92019, Auckland 1142. Telephone: 09 373 7599 extn. 83711. Email: ro-ethics@auckland.ac.nz

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON…03/07/2015…… for (3) years, Reference Number…….015115…….

Appendix K: Consent Form – Interview Participants

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau
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The University of Auckland
Private Bag 92019
Auckland, New Zealand

Consent Form – Interview Participants

THIS FORM WILL BE HELD FOR A PERIOD OF 6 YEARS

Project title: **When does Lean Production Enhance Employee Wellbeing?**
Researcher: **Menglong Huo**

I have read the participant information sheet, have understood the nature of the research. I have had the opportunity to ask questions and have them answered to my satisfaction.

- I agree to take part in this interview.
- I understand that my participation is entirely voluntary and interview information will not be electronically recorded.
- I understand that I am free to withdraw at any time during the interview.
- I agree to not disclose anything discussed in the interview.
- I understand that the fact of my participation or non-participation in this interview will have no effect on my employment status.
- I wish/do not wish to receive a summary of survey findings.

If you wish to receive a summary of survey findings, please enter an email address here:

____

Name_________________________

Signature______________________ Date_________________

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON…03/07/2015…… for (3) years, Reference Number…….015115……

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