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CICLO XXXII

THE EFFECT OF LEAN MANUFACTURING ON EMPLOYEE WELL-BEING: THE ROLE OF SOFT LEAN PRACTICES

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Abstract

Today, lean is a widespread management approach in manufacturing companies, thanks to its proven positive impact on operational performance (i.e., efficiency, quality, flexibility and responsiveness). One aspect that remains barely comprehended by companies implementing lean, is the impact of lean practices on employee well-being. In particular, the present doctoral thesis is based on an analysis of scientific literature concerning lean and employee well-being. This analysis has allowed to detect that a clear-cut position is not yet available in the literature, and to highlight which are the main gaps. As regards the manufacturing context, Just-in-Time (JIT) practices have been mainly associated with worse working conditions, and soft lean practices (i.e., those lean practices related to employee involvement) have seemed to play a positive role for employee well-being. However, the discussion is far from being close and these lean aspects are rarely quantitatively assessed. Furthermore, few previous studies have quantitatively investigated the interaction between different lean-related aspects on employee well-being, with even inconclusive results. Starting from specific identified gaps, the present work develops several hypotheses based on lean literature and a consolidated psychological model, in order to further comprehend the impact of specific lean-related job aspects and their interaction, on two well-being measures, work engagement and exhaustion. The developed hypotheses have been tested through a quantitative study based on a questionnaire administered to 147 workers employed in an Italian plant of a multinational home appliances corporation. The results support the positive impact of soft lean practices on employee well-being, the negative impact of JIT-related work characteristics on employee well-being, the higher salience of soft lean practices on work engagement for those workers who perceive higher levels of JIT-related work characteristics, and the capacity of soft lean practices to alleviate the impact of JIT-related work characteristics on employee exhaustion. From the theoretical and practical point of view, the most important contribution of this research is represented by the quantitative confirmation of the ability of soft lean practices to mitigate the negative impact of JIT on employee well-being. The study also shows that workers exposed to more wearing conditions in terms of JIT, have a well-being level comparable with that of those colleagues exposed to less demanding conditions, thanks to their involvement in soft lean practices.

Sommario

Il lean è oggi un approccio gestionale ampiamente diffuso nelle aziende manifatturiere grazie al suo comprovato impatto positivo sulle performance operative in termini di efficienza, qualità, flessibilità e reattività. Un aspetto che tuttavia rimane scarsamente compreso dalle aziende attive nell'implementazione del lean è l'impatto delle pratiche lean sul benessere dei lavoratori. In particolare, la presente tesi di dottorato si sviluppa a partire da un'analisi della letteratura sul tema del lean e del benessere organizzativo. Tale analisi ha permesso di rilevare la posizione non ancora chiara della letteratura e di evidenziare quali sono i gap principali. Con riferimento al contesto manifatturiero, le pratiche legate al Just-in-Time (JIT) sono state chiaramente associate ad un peggioramento del benessere dei lavoratori, mentre le pratiche lean soft (i.e., quelle pratiche lean orientate al coinvolgimento delle persone) sembrano aver giocato un ruolo positivo per il benessere dei lavoratori. Tuttavia, la discussione è ancora aperta e raramente questi aspetti sono stati valutati quantitativamente. Inoltre, pochi studi precedenti hanno approfondito quantitativamente l'interazione tra differenti aspetti legati al lean sul benessere dei lavoratori, con anche risultati non conclusivi. Partendo dagli specifici gap identificati, il presente lavoro sviluppa una serie di ipotesi sulla base della letteratura sul lean e su un modello psicologico consolidato, al fine di approfondire l'impatto di specifici aspetti lavorativi legati al lean e della loro interazione, su due misure di benessere, ingaggio ed esaurimento dei lavoratori. Le ipotesi sviluppate sono poi state testate attraverso uno studio quantitativo basato su un questionario somministrato a 147 lavoratori *blue-collar* appartenenti ad un plant italiano di una multinazionale produttrice di elettrodomestici. I risultati ottenuti supportano l'impatto positivo delle pratiche lean soft sul benessere dei lavoratori, l'impatto negativo degli aspetti lavorativi legati al JIT sul benessere dei lavoratori, la maggiore rilevanza delle pratiche lean soft sul coinvolgimento dei lavoratori che percepiscono livelli più elevati di richieste lavorative relative al JIT, e la capacità delle pratiche lean soft di alleviare l'impatto delle richieste lavorative relative al JIT sull'esaurimento. Dal punto di vista teorico e pratico, il contributo più rilevante è rappresentato dalla conferma quantitativa della capacità delle pratiche lean soft di mitigare l'impatto negativo del JIT sul benessere dei lavoratori. Lo studio mostra inoltre che i lavoratori soggetti a condizioni più gravose in termini di richieste lavorative legate al JIT, possano comunque avere un benessere comparabile con quello dei colleghi sottoposti a condizioni meno gravose, grazie proprio al coinvolgimento nelle pratiche lean soft.

Contents

1. Introduction

1.1. Overview of the Thesis

This manuscript is based on a three-year research activity on lean, and, specifically, on the impact of lean on employee well-being. In particular, the core of this thesis is a theory-testing research that applied a specific psychological model in order to provide quantitative evidence of the positive role of human-oriented lean practices (i.e., soft lean practices), and specifically, the unproven claim that these Soft Lean Practices (SLP) can reduce the negative impact of other lean-related job aspects on well-being.

The research topic is particularly relevant since lean is a widespread approach in manufacturing companies thanks to its proven positive impact on operational performance (i.e. efficiency, quality, flexibility and responsiveness). Moreover, in recent times, lean has played a strategic role for manufacturing companies facing harsh contextual conditions such as stagnant or recessive markets.

However, one aspect that remains poorly considered by companies is the impact of lean on the workers' well-being. Most of the time, managers are not aware of the potential drawbacks of lean in terms of work intensification and work-related stress. This aspect is exacerbated by the fact that many organizations apply lean as a bunch of technical tools, with no regards for human-related aspects and employee involvement. This culminates in limited and harmful applications of lean, with arguable results in terms of both performance improvement and impact on employees.

This work starts from this practical consideration and moves into scientific literature in order to further understand the impact of lean on employee well-being and provide an original contribution on the topic.

The next section of this chapter offers a broad overview of the construct of lean that is central in the current research, and the last section briefly shows the structure of the thesis in order to guide the reader in the following chapters.

1.2. Background on Lean

The concept of lean is rooted in the post-World War II Japanese industry, in particular in the innovations made in Toyota (Ohno, 1988; Shingo, 1981), due to resources shortage and intensification of internal competition. The managerial and production approach adopted by Toyota - better known as the Toyota Production System (TPS) - was based on the systematic elimination of all forms of non-value-added elements such as stocks.

The term lean was firstly introduced by the American researcher Jhon F. Krafcik (1988) to highlight the low inventory distinctive characteristic of the TPS, in contrast with traditional capital intensive mass production Fordism, based on physical redundancies, and conversely defined as buffered production system. The diffusion of lean happened thanks to two other American authors: James P. Womack and Daniel T. Jones, with their first book "The Machine That Changed the World" (1990), in which they compared lean with non-lean plants and shew TPS benefits in terms operational performance improvement. Later, Womack and Jones proposed deeper insights on lean and its guiding principles in "Lean Thinking: Banish waste and create wealth in your corporation" (Womack and Jones, 1996). In this book the authors identified what they believed were the founding principles of lean: (1) Value, (2) Map, (3) Flow, (1) Pull, (5) Perfection. According to Womack and Jones, the first foundation element of lean thinking is the correct identification of customer value, defined as all those product or service elements that the customer is willing to pay. The second building principle of lean requires to properly map the product/service flow through which the value is created, starting from the beginning (raw material in the case of the physical product) and identifying all the activities that occur. Based on value definition, activities are classified in: value-added and non-value-added (in Japanese *muda* - defined as those activities that absorb resources without contributing to create value). The seven main *mudas* were identified and described by Ohno (1988), recognized as the TPS father, and are: (1) over-production, (2) waiting, (3) transportation, (4) over-processing, (5) inventory,

(6) motion of workers, (7) defects[1]. Following the path outlined by Womack and Jones, lean thinking is then realized through systematic removal of those elements that obstacle a continuous flow of materials and information through exclusively value-added activities, and through the adoption of pull-based processes which are triggered by customer demand. Finally, according to the fifth and last principle, it is necessary to continuously iterate improvements[2] through systematic application of the previous principles in order to expose and always attack new emerging *mudas*, aiming at perfection.

Since its first formulation in the '90s, the interest in the lean phenomenon has been constantly growing, with many success cases in the manufacturing context. More recently lean application has moved beyond the mere production context and it is now used to improve very different processes such as new product development (lean product development) or healthcare ones (lean healthcare - Netland and Powell, 2016). From an academic standpoint, researchers have started talking of lean management to identify the general application of the lean principles, regardless of the context.

In a comprehensive way, lean management can be defined as an integrated sociotechnical system, which aims at streamlining the value-creation flow, concurrently reducing *muda*, minimizing external and internal variability and involving employees in continuous improvement (Shah and Ward, 2007; de Treville and Antonakis, 2006). It is possible to group lean tools in four different bundles (Shah and Ward, 2003):

- Just in time (JIT): includes all those practices focused on reducing and eliminating all forms of waste, mainly process inventories and unnecessary flow delays.
- Total quality management (TQM): includes the practices aimed at constantly improving quality.
- Total preventive maintenance (TPM): includes those tools oriented to preventive and

[1] Literature recognizes an eighth *muda* that is the underutilization of intellectual capacity. It reflects the central role that human beings should play in the Toyota Production System and lean adoption according to lean theorists.

[2] In Japanese the word *kaizen*, that means continuous improvement, is generally adopted to better describe this last principle.

predictive maintenance.

- Human resource management (HRM): includes those human-oriented practices promoting employee involvement.

These different groups of lean tools underpin the distinction between soft and hard lean (Bortolotti, Boscari, et al., 2015). Soft lean practices are those related to employee involvement, whilst hard tools are those analytical and technical elements of lean.

1.3. Thesis Structure

The thesis is structured as follows.

Chapter 2 presents the systematic literature review performed on lean and well-being. It firstly describes the methodology adopted to rigorously survey scientific literature and then it shows most relevant results. In the last two sections major detected gaps are described and a specific research question, guiding the empirical analysis, is formulated.

Chapter 3 describes the performed research aiming at investigating the role of soft lean practices in affecting employee well-being. The chapter firstly offers a deeper understating of a specific psychological model adopted for building several hypotheses on lean-employee well-being relationship. After hypotheses development, the investigated context, adopted measures, data collection procedure and scale validation are illustrated. Results are finally presented in the last section.

Finally, Chapter 4 discusses the results focusing on both theoretical and managerial contributions. In the last part, major research limitations and future research opportunities are presented.

2. Literature Review

2.1. Overview of the Chapter

This chapter presents the results of a structured literature review, performed on the topic of lean and employee well-being. It firstly presents the methodology utilized in order to survey the scientific literature. Secondly, literature review results are reported, showing the most relevant aspects, and third, gaps and research opportunities are presented. Finally, the research question driving the empirical study is presented.

2.2. Methodology

A systematic literature review is a crucial method that follows a specific, replicable, transparent and scientific procedure in order to meticulously scrutinize scientific publications on a precise topic of research (Tranfield et al., 2003). The general objective of a literature review is to provide a precise portrait as regards the state of the art of the chosen topic, highlighting consolidated knowledge, but also new lines of research and potential gaps to address. Moreover, during a Ph.D. course, a literature review represents a training activity during which the aspiring researcher defines a researchable topic, collects information as regards constructs and theories, and builds critical research skills (Karlsson and Åhlström, 2016).

In agreement with specific literature review guidelines (Kitchenham and Charters, 2007; Tranfield et al., 2003), this systematic literature review was based on three essential stages: (1) the planning, (2) the conducting and (3) the reporting phases. In the first phase, the planning one, a literature review research question was specified in order to guide the entire review process. Then, with the literature review research question as a starting point, a research protocol was developed, in order to specify the methods for literature query and minimize research biases while maximizing generalisability, reliability and reproducibility of the findings. Once the protocol had been defined, the conducting phase was performed selecting the most relevant studies on the topic in specific databases and extracting the most relevant information. This allowed to build a database containing all relevant dimensions as regards the selected papers. The obtained database was then extensively investigated in order to extract and synthetize all relevant aspects concerning the literature state of the art and provide a list of major gaps on lean and employee well-being. The reporting phase is considered as constituted by results reported in this thesis and related scientific articles, and their dissemination.

Although the above steps seem to follow a logic and chronologic order, during the literature review process several iterations were performed in order to adapt and update previous steps to specific information made available only during subsequent steps of the process. For example, inclusion and exclusion criteria for study selection and data extraction form were specified at the beginning of the literature review process within the research protocol, but they were refined and updated several times later thanks to the new information collected during the review process.

In the next sections, detailed information on the planning and the conducting phases are provided.

2.2.1. Literature Review Research Question

In order to guide the initial phase of literature reviewing, it is important to define the literature review research question. The research question is a fundamental criterion that permits to identify the related studies and to extract only the significant information through a proper extraction form. Ideally, the collected data should be then synthesized in order to close the loop and answer the research question.

In this research, readers can assume the following research questions as key driver for the literature review:

RQ: *What pieces of evidence are available on the relationship between lean and the employee well-being?*

The aforementioned research question clearly intended to investigate the effect of lean on employee well-being. A PICOC framework was applied to critically consider and specify all the different elements of the research questioning: Population, Intervention, Comparison, Outcomes and Context (PICOC - Petticrew and Roberts, 2008). PICOC elements are displayed in Table 1.

DIMENSION	DESCRIPTION
Population	Employees directly or indirectly involved in lean initiatives
Intervention	Any kind of structured implementation of lean or TPS (e.g., lean manufacturing, TPS-inspired production systems, lean office/service, lean healthcare and other lean application beyond those previously cited)
Comparison	Organizations/groups/units not applying or with low level of lean Employees not exposed or less exposed to lean Vs. Organizations/groups/units with high implementation level of lean Employees directly or indirectly exposed to lean (even the comparison of the same organizations pre and post intervention)
Outcomes	Employee well-being related outcomes
Context	Manufacturing or service contexts, private or public organizations, considering any kind of job

Table 1 PICOC framework the literature review

It is worth noting here that literature review boundaries were kept as wide as possible including private, public organization, both implementing lean in transformational or transactional processes, in service or manufacturing contexts. These boundaries will be discussed in the review protocol in the section below.

2.2.2. Review Protocol

In order to ensure the quality of the literature review in terms of generalisability and reliability, and reduce the possibility of researcher bias to affect the process, a specific research protocol was developed following Kitchenham and Charters's guidelines (2007). In addition to the research question, research strategy, exclusion and inclusion criteria, and data extraction form have been included in the protocol.

2.2.2.1. Research Strategy and Inclusion Criteria

In the research strategy the search terms and resources to be searched were specified, defining the inclusion criteria. Starting from the research question, two major groups of keywords related to the two constructs of lean and employee well-being were identified. The constructs, their definition and the adopted keywords are reported in Table 2.

The first block regarded lean and included the most relevant keywords utilized to encompass any kind of lean implementation performed in an organization. Examples are “lean manufacturing”, “lean production” or “lean healthcare”. It should be pointed out that in addition to the term “lean”, the term “Toyota production system” was included since many companies have adopted lean philosophy, strategy, principles and tools creating their own production system, inspired to the Toyota’s one (Netland, 2012). Moreover, keywords referring to Just-In-Time production (i.e. JIT, just in time, just-in-time) were included because they are strictly related to lean. JIT refers to the practice of producing a product or a service just in time for its consumption. This results in minimizing overproduction considered as a waste and a source of further wastes such as inventory (Hopp and Spearman, 2004). Taiichi Ohno, considered as the father of lean, in his seminal book on the Toyota production system (1988), defined JIT as an essential pillar of the TPS along with *jidoka* (autonomation). Even in the first practical publications on the TPS, JIT production was regarded as the crucial element of the Japanese production success (Hall, 1981; Schonberger, 1982; Zipkin, 1991), and in early scientific literature on lean and employee well-being, scholars refer to lean introduction as just-in-time introduction (Groebner and Mike Merz, 1994; Jackson and Martin, 1996; Mullarkey et al., 1995). Therefore, it is clear that JIT phenomenon is part of lean since it was “born and bred” under the lean umbrella, even though today it is just a portion of lean management.

On the contrary, terms related to other production approaches such as Total Quality Management (TQM) or Six Sigma were not included in the selected material, with the clear purpose of including only researches that investigated the “lean” phenomenon standalone, without any form of hybridization or mixing that may eventually shed doubts on the results. This is because, in contrast with JIT, managerial approaches such as TQM and Six Sigma were born in different contexts with different aims in comparison with lean. As a consequence, they are not closely related to lean philosophy and lean principles, despite synergies and integrations may eventually exist.

As regards the second block, keywords related to employee well-being were included, considering terms directly related to employee well-being outcomes (i.e., well-being, motivation, satisfaction, strain, stress, commitment, engagement, health), specific effects on workplace characteristics (i.e., autonomy, control, ergonomics, job design, intensification, workplace), and the workers' perception (i.e., workers' perception, working conditions, working life).

This choice was in line with different conceptualization of well-being at work (e.g, health-related well-being, psychological well-being) and with the dominant approaches in the occupational health literature to differentiate work characteristics from strain (Edwards et al., 2008). Moreover, the defined set of keywords was compared and validated, cross-checking those utilized in previous published literature reviews on the topic (Hasle et al., 2012; Koukoulaki, 2014; Landsbergis et al., 1999).

CONSTRUCTS	DEFINITION	KEYWORDS
LEAN	Integrated socio-technical system, firstly developed in Toyota, whose main objectives are streamlining the production, reducing muda, minimizing external and internal variability and involving employees in continuous improvement (Shah & Ward, 2007, de Treville & Antonakis 2006)	lean, Toyota production system, jit, just in time, just-in-time
EMPLOYEE WELL-BEING	Health-related quality of employee's experience and functioning at work, related to negative and positive aspects of the work (Chen and Cooper, 2014; Van De Voorde et al., 2012)	WELL-BEING OUTCOMES: well-being, motivation, satisfaction, strain, stress, commitment, engagement, health WORKPLACE CHARACTERISTICS: autonomy, control, ergonomics, job design, intensification, workplace, job attitude, work design WORKERS' PERSPECTIVE: workers' perceptions, working conditions, working life, employees' perspectives

Table 2 Construct definitions and adopted keywords

Since the scope of the review is to synthetize sound scientific evidence on the impact of lean on employee well-being, the research was focused only on scientific peer-reviewed researches written in English language. The two most important scientific databases were queried: Scopus and Web of Knowledge. This choice aimed at providing a wide coverage of the scientific activity in the management and engineering fields of research. The selected keywords were searched in title and authors keywords in the Scopus database, and in the title field for Web of Knowledge database. This research approach allowed to balance the tradeoff between number and relevance of the results. As regards the investigated time span, any research published before February 2018 was considered, whereas no lower time limit was introduced.

Only scientific contributions, both empirical or theoretical, were included. Literature reviews were not included in the process, but they were carefully considered separately since they were precious source of information for protocol development.

In addition to the papers retrieved through the above-mentioned procedure, other relevant researches were added during the literature review analysis phase following a snowball strategy. Analyzed papers' references were used as a further source of relevant researches that were added to the final database where all the criteria were met.

2.2.2.2. Exclusion Criteria

After database query, several exclusion criteria were applied in order to keep out those manuscripts that did not meet the scope of the review. The applied exclusion criteria are listed below (Table 3) according to the logic and chronologic sequence followed during the process.

N°	EXCLUSION CRITERIA	DESCRIPTION
1	Exclusion of duplicated articles	Exclusion of duplicated articles in order to ensure univocity of included researches. This criterion was applied checking title, authors, journal and year.
2	Exclusion of articles not concerning lean	Exclusion of those articles that did not primarily concern lean and the term lean did not refer to the application of the principles and practices related to the Toyota Production System (e.g., articles referring to other fields of engineering or medicine). The exclusion was based on title, keywords, abstract scanning. In case of doubt the article was accepted to the next stage.
3	Exclusion of articles reporting partial/hybrid/mixed application of lean	Exclusion of those articles reporting partial application of lean (e.g., only a specific tool such as 5s), an hybrid application of lean with other managerial approaches (e.g., lean and agile) or referring to lean as part of a broader range of managerial techniques (e.g., new forms of work organizations) since the scope of this research is study the isolated effect of lean on employee well-being. This choice reflects the idea that lean is a philosophy that should be implemented as a whole, rather than a bunch of specific tools applied idiosyncratically. The exclusion was based on title, keywords and abstract scanning. In case of doubt the article was accepted to the next stage.
4	Exclusion of articles not related to lean and employee well-being.	Exclusion of those article that are not related to the impact of lean on employee well-being. Exclusion was firstly based on title, keywords and abstract. In case of requirements compliance or uncertainty, the article was admitted to next phase of full text reading. All articles admitted to full text reading were meticulously read and, if they contained relevant scientific pieces of evidence as regards lean and employee well-being, they were included in the final version of the literature review database. Otherwise, the articles were discharged.

Table 3 Exclusion criteria

Based on full text reading a total number of 54 articles were included in the final database (see Appendix A). Figure 1 depicts the exclusion criteria application with the number of articles obtained after each stage. Snowball-added articles are reported in the last stage.

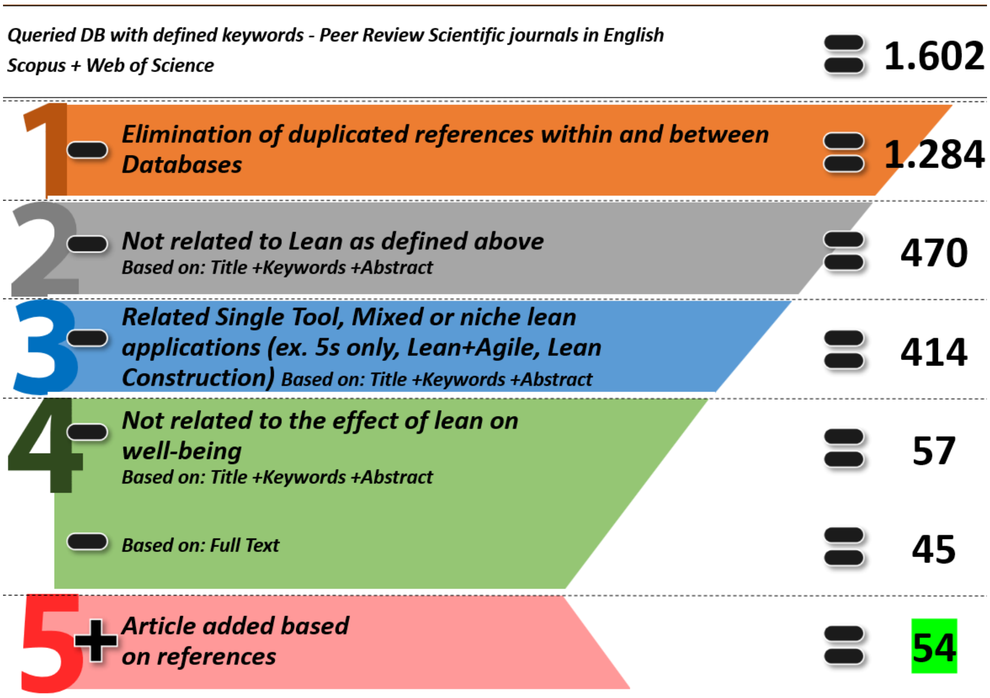

Figure 1 Results of the application of exclusion criteria.
The final database included 54 articles.

2.2.2.3. Data Extraction Form

Within the research protocol, a data extraction strategy was defined in order to collect all relevant information from those studies included in the database. As for the inclusion strategy, even the data extraction strategy was updated during the process of paper scanning and full text reading in case other dimensions had appeared as relevant and interesting for the research scope.

The data extraction strategy brought to the definition of a data extraction form containing all dimensions considered as relevant for the literature review, as reported in Table 4.

Where available, all previous pieces of information were extracted from included papers through full text reading. Figure 2 is to be seen as an example to better explain the followed procedure. It displays some of the dimensions part of the data extraction form and the database.

Once defined inclusion and exclusion criteria and the extraction strategy, the literature review was performed iteratively updating the protocol when needed. All selected papers were included in a database containing all relevant information. Database manipulation allowed the analysis and the summarizing of all interesting aspects of the body of knowledge regarding lean and employee well-being.

TYPE OF RETRIVED INFORMATION	LIST OF EXTRACED DIMENSIONS
Article and journal generic information:	Title of the research, journal name, volume, issue, year, topic, Scimago H-index, AiIG journal classification, topic
Authors' information	Names, affiliation and country at the time of publication
General information on the research design	Research question(s), research approach (i.e., theoretical, quantitative, qualitative, mixed), further details about the methodology, time perspective (i.e., cross-sectional, longitudinal), single/multi country study, countries of research, unit of analysis, sample information, general researched sector (automotive, other manufacturing, service, mixed), specific researched sector(s)
Lean information	Type of lean measurements (i.e., qualitative, quantitative), mentioned/measured lean practices, lean implementation strategy, lean implementation context
Lean and well-being information	Theoretical perspectives of stress/well-being measurements, measured/mentioned job characteristics and effect, measured/mentioned outcomes and lean effect on these outcomes, overall effect of lean according to the authors, overall effect of JIT tools, overall effect of preventive maintenance tools, overall effect of quality tools, overall effect of human-related lean tools ,results and contribution, identified gaps

Table 4 Data extraction form dimensions

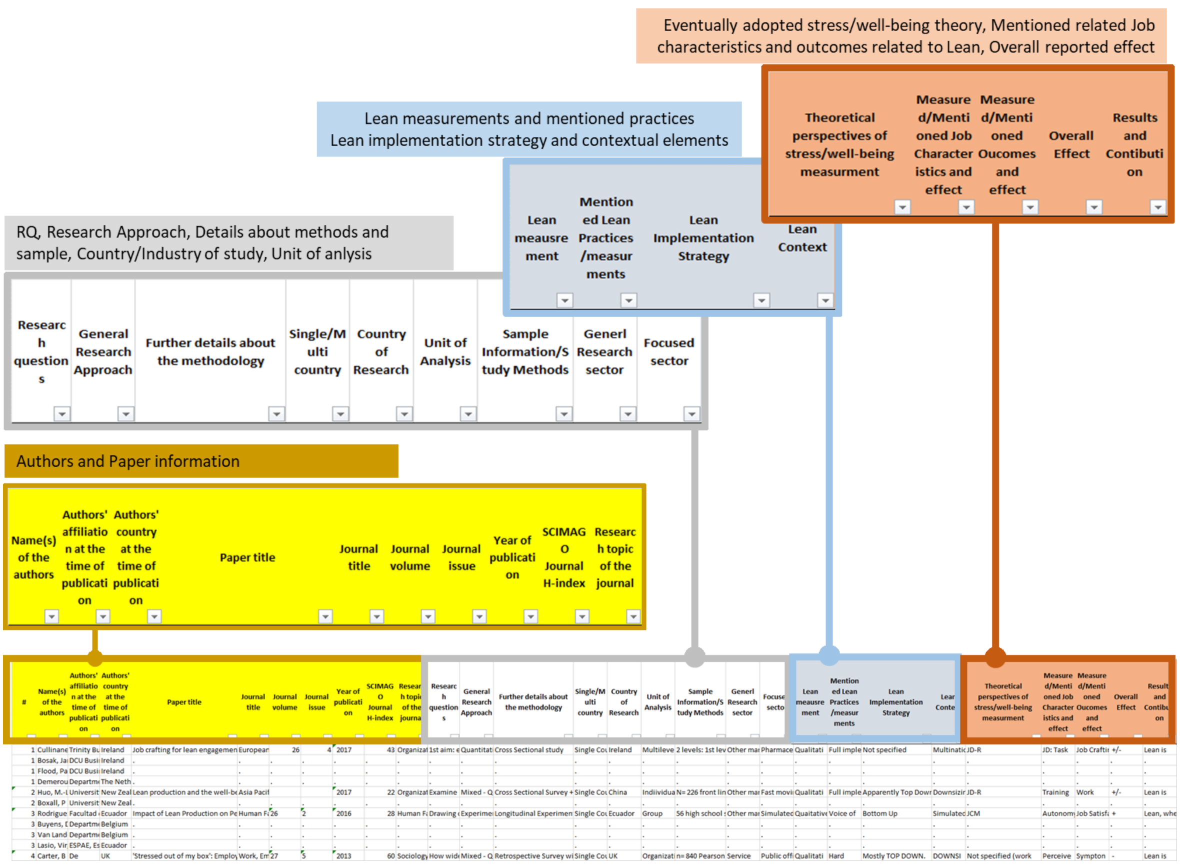

Figure 2 Database picture with a zoom on the data extraction form

2.3. Analysis and Results

In this section, I report the results of the literature review process with the aim of both providing an updated picture of the research on lean and employee well-being and of trying to answer the literature review research question.

2.3.1. General Descriptive Analysis

It is worth noticing that the issue of the impact of lean on employee well-being has been addressed in many fields of research, with the majority of the publications belonging to the category "Public Health, Environmental and Occupational Health" (11 papers), followed by "Organizational Behaviour, Human Resource Management and Applied Psychology" (10 papers), "Human Factors and Ergonomics" (9 papers), "Business Management and Accounting" (9 papers) and "Operations Management" (8 papers). The results regarding the journals where the different contributions appeared are reported (Figure 3).

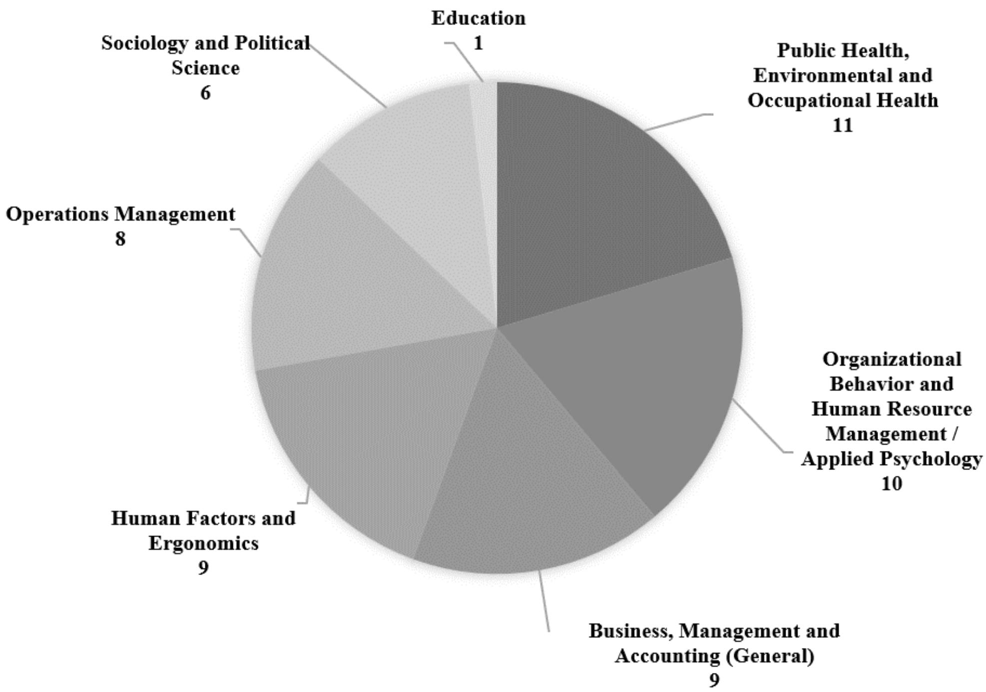

Figure 3 Contributions on the effect of lean on employee well-being per journal topic

On the one hand, most of the papers in health-related journals are clearly connected with the interest of occupational health scholars in investigating the effect of lean manufacturing (i.e., application of lean in a manufacturing contexts/processes) on occupational stress and satisfaction on the workplace (Brown and O'Rourke, 2007; Håkansson, Holden, et al., 2017; Jackson and Mullarkey, 2000; Lipińska-Grobelny and Papieska, 2012). On the other hand, 5 out of those 11 contributions in health-related journals are researches that investigated the effect of lean healthcare (i.e., application of lean in a healthcare contexts/processes) on employee well-being (Drotz and Poksinska, 2014; Lindskog et al., 2016; Simons et al., 2017; Smith et al., 2012; Ulhassan et al., 2014). For these 5 papers the journal choice was probably dictated by the lean implementation context.

As regards the other topics, two different perspectives emerge. On the one side, "Organizational Behaviour, Human Resources Management and Applied Psychology" fields have been primarily focused on the psychological effects of lean considering outcomes such as work engagement, commitment, motivation, psychological stress and exhaustion. On the other side, "Human Factors and Ergonomics" scholars have been focused on both psychological and physical aspects, considering, in addition to psychological outcomes, even physical well-being measures (e.g., Dellve et al., 2015; Saurin and Ferreira, 2009; Womack et al., 2009).

Concerning the quality of the considered publications, 50 out of 54 papers were published in SCImago ranked journals (SCImago Institutions Rankings, 2018). While as for the Italian AiIG ranking of international journals (AiIG, 2018), 17 papers belong to GOLD or GOLD* category, 10 belong to SILVER journals, 6 belong to BRONZE journals and the others are not included in the list.

Figure 4 reports the global number of publications per year, and next to it, publications in the manufacturing and in the service industries are displayed. The picture supports that an increasing interest in the topic has been recently developed, mainly due to the raising attention to the application of lean outside of the manufacturing context. Before 2010, in just a couple of publications researchers have tried to investigate the effect of lean on well-being in services (Schultz et al., 1998; Sprigg and

Jackson, 2006), and in one of these cases (Schultz et al., 1998), the focus was to gain a better understanding of lean manufacturing, through the study of simpler transactional processes. Conversely, 15 out 27 studies published after 2010 focused on lean applications in service contexts (Bäckström and Ingelsson, 2015; Carter et al., 2013; de Haan et al., 2012; Ingelsson and Bäckström, 2017; Procter and Radnor, 2014), and mainly on lean healthcare applications, with 10 studies (Dellve et al., 2015, 2018; Drotz and Poksinska, 2014; Füllemann et al., 2016; Holden et al., 2015; Lindskog et al., 2016; Simons et al., 2017; Smith et al., 2012; Stanton et al., 2014; Ulhassan et al., 2014).

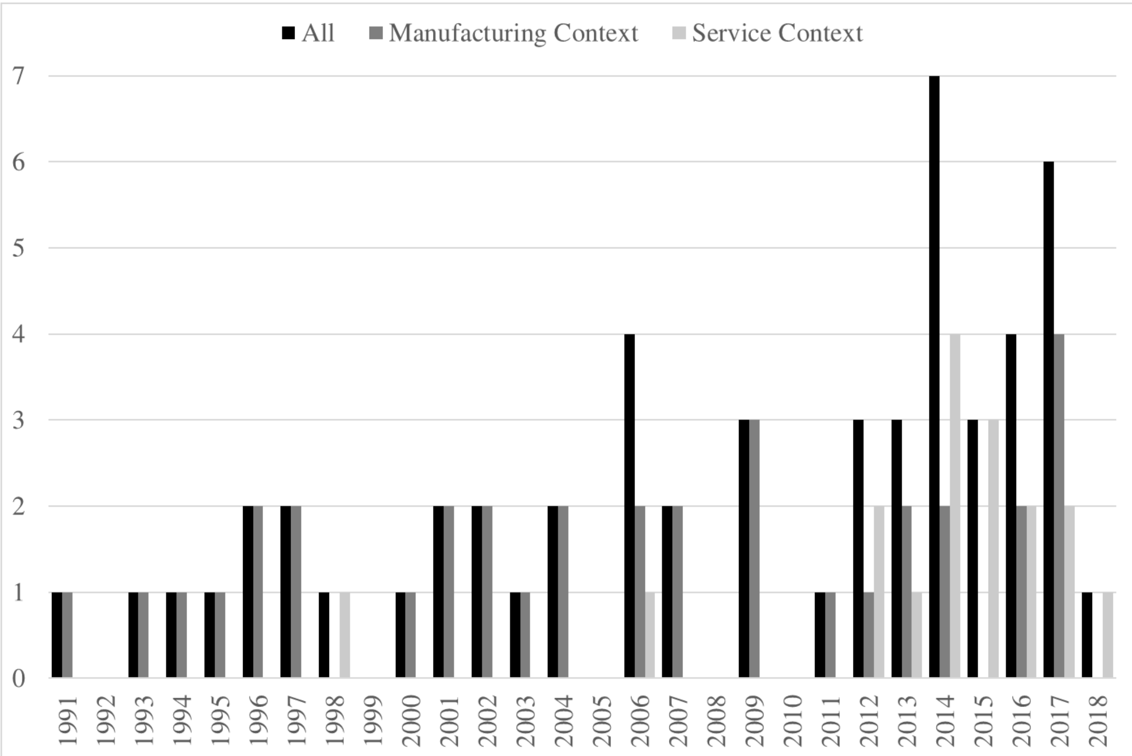

Figure 4 Publications per year (overall, manufacturing and service contexts)

Considering the methodologies applied by researchers in order to investigate the phenomenon, there is a clear predominance of quantitative methods with 20 researches that adopted a purely quantitative approach, whereas other 18 researches integrated a quantitative with a qualitative approach, performing some sort of interviews (Figure 5).

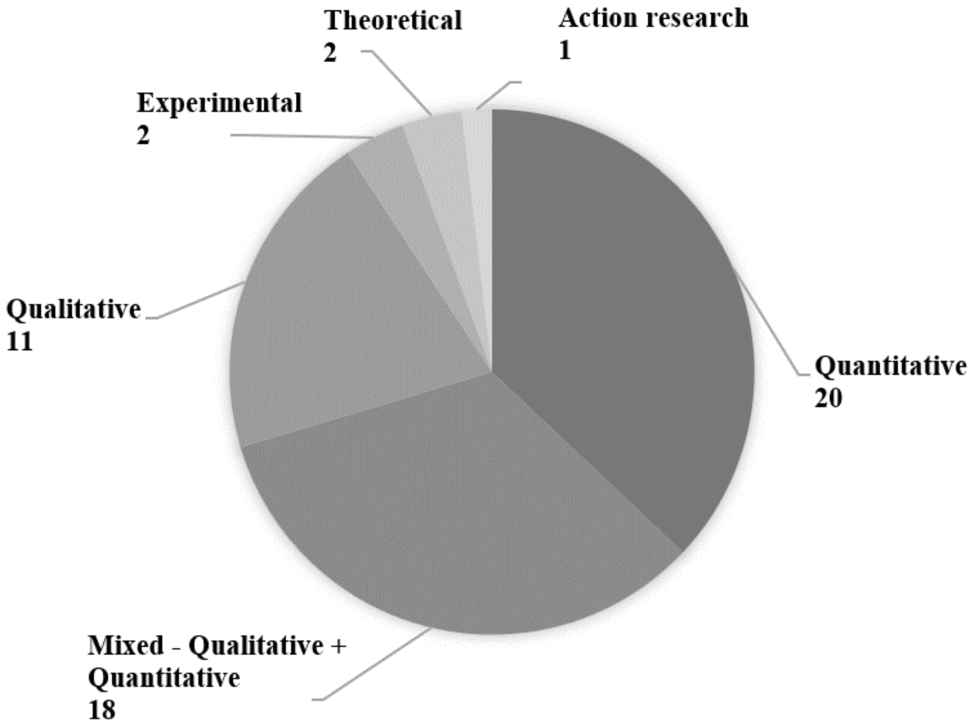

Figure 5 Researches divided per methodology.

In relation to the time perspective, 27 studies adopted a cross-sectional viewpoint, 20 a longitudinal viewpoint, and 5 mixed both cross-sectional and longitudinal data (the remaining 2 articles are purely theoretical - de Koeijer et al., 2014; de Treville and Antonakis, 2006)

A further interesting consideration can be made on the unit of analysis since there is an important variability among the included studies (Table 5). Considering that lean can generally be applied at organization, plant or business unit level, an important number of studies tried to investigate the impact of lean having the organization or the plant as the focal unit of analysis (Drotz and Poksinska, 2014; Lewchuk et al., 2001; Lewchuk and Robertson, 1997; Longoni et al., 2013). In this case, researchers adopted both a cross-sectional perspective, comparing different plants based on the lean application and the "average" effect on employees (e.g., Lewchuk and Robertson, 1996, 1997; Longoni et al., 2013; Vidal, 2007a; Yates et al., 2001), and a longitudinal perspective, trying to compare the organizational conditions pre and post lean application (Håkansson, Dellve, et al., 2017; Håkansson, Holden, et al., 2017; Mullarkey et al., 1995). Some other studies tried to adopt a more fine-grained approach, considering as unit of analysis the individual employee (Cullinane et al., 2013;

de Haan et al., 2012; Schouteten and Benders, 2004; Sprigg and Jackson, 2006). In this context, scholars recognized that it was crucial to directly involve employees in the research when well-being is under investigation. Some of them also highlighted the importance of not averaging well-being in a single company index since well-being is an individual phenomenon, and the experience of lean can significantly differ among workers belonging to the same plant or organizational unit. Additionally, a consistent number of studies (11) even tried to mix organizational-level data with individual-level data, claiming that they had assumed a multilevel perspective.

The variegated picture in terms of considered units of analysis is strictly connected to the complexity of the lean-well-being phenomenon. As mentioned above, lean is generally applied and studied at organizational or business unit level, however its effect in terms of well-being occurs at individual level (since well-being is an individual phenomenon). The lean -well-being relationship can be considered as a multi-level one, where different elements at different levels of analysis interact and affect each other. This crucial aspect has led scholars to face a trade-off between generalisability at plant-level and depth of the data collected, leading in the first case to gather "averaged" organizational-level data of several different organizations, and in the second case to consider individual-level data belonging to one or few plants. It is relevant to highlight that just 2 papers (Cullinane et al., 2017; Füllemann et al., 2016) that claimed a multi-level perspective, consistently adopted multi-level methodology (Hox et al., 2010).

N° ARTICLES PER UNIT OF ANALYSIS	
Organization/Plant	22
Multiple/mixed level of analysis	11
Individual	9
Team/Group	6
Organizational Unit/Processes	4
Production Jobs	1
Project	1

Table 5 Contributions divided per unit of analysis

2.3.2. Specific Results on the Effect of Lean on Employee Well-Being

2.3.2.1. The overall effect of Lean on employee well-being

Considering the overall effect of lean on employee well-being, results appear as mixed. Figure 6 shows the number of papers that clearly reported an effect of lean on employee well-being. Their division was based on the proposed effect of lean on well-being (positive, negative, both positive and negative or no change) and the year of publication.

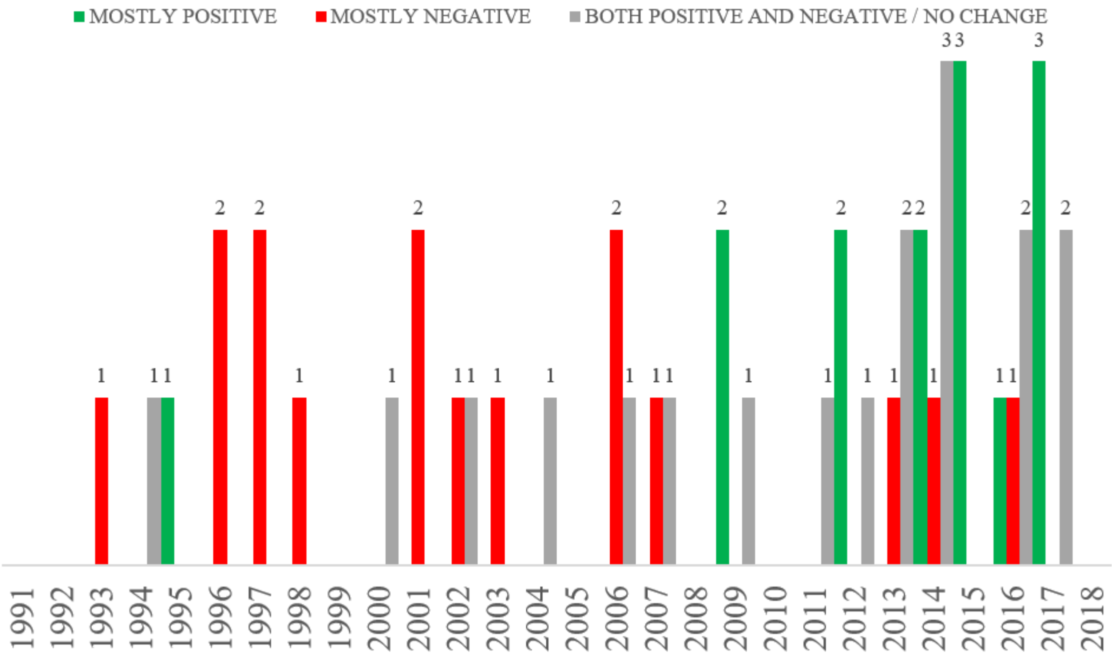

Figure 6 Researches divided per overall effect of lean and year of publication.
Note: 4 papers have been excluded from the picture due to lack or unclear information on the overall effect of lean. Other 2 papers were not included since they were purely theoretical contributions

This picture is quite revealing in several ways. Firstly, what stands out is that the papers claiming a negative effect of lean on employee well-being (in red) are mainly located between 1990 and 2010. Just few studies after 2010 reported a purely negative effect of lean on employee well-being. Secondly, the figure clearly shows that in recent years there has been a sharp rise of researches claiming that lean is mostly positive for workers well-being (in green). Thirdly, an important number of studies recognized that lean is not entirely good or bad, or reported no change in well-being due to lean.

2.3.2.2. Lean Effect: Manufacturing vs. Service

Figure 7 and Figure 8 report the number of papers divided per effect and year of publication in the manufacturing and service sectors respectively.

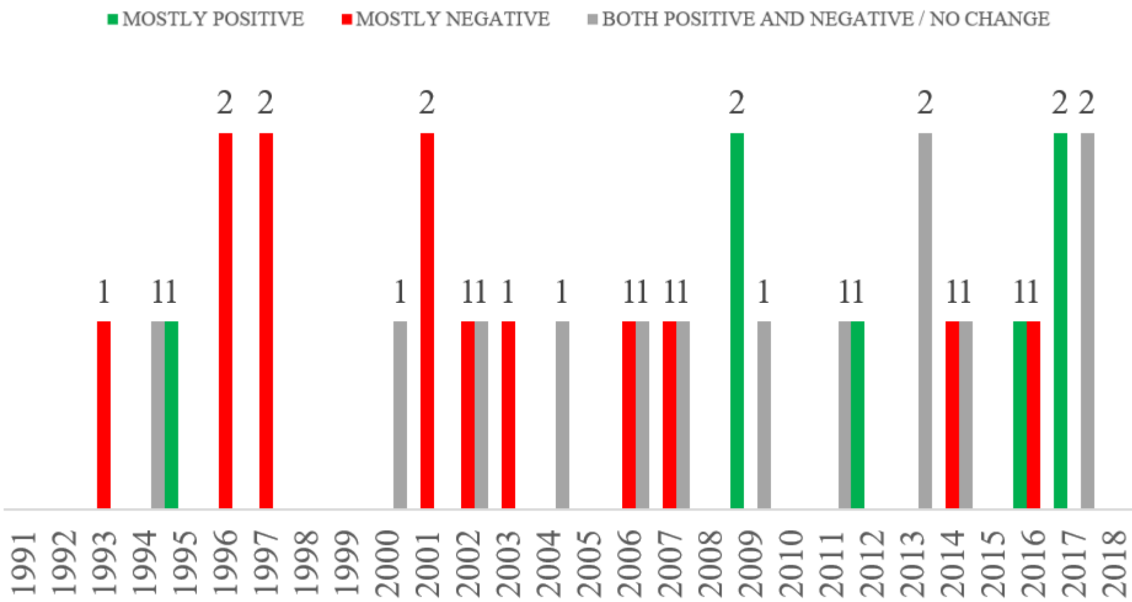

Figure 7 Researches conducted in ***manufacturing sector****, divided per overall effect of lean and year of publication*
Note: 2 papers have been excluded from the picture due to lack or unclear information on the overall effect of lean

What is interesting about the pictures is that most of the negative results refer to researches conducted in the manufacturing field (Figure 7), and again mainly between 1990 and 2010. Therefore, it appears that the application of lean in the manufacturing context has been predominantly associated with a deterioration of working conditions and employee well-being. Going deeper in those studies reporting a negative effect, it is clear that a conspicuous number of these researches focused on the automotive industry, where 10 out of 12 studies (Adler et al., 1997; Babson, 1993; Bruno and Jordan, 2002; Lewchuk et al., 2001; Lewchuk and Robertson, 1996, 1997; Mehri, 2006; Parker, 2003; Stewart et al., 2016; Yates et al., 2001) supported that lean had predominantly a negative effect on workers in terms of health (higher work-related musculoskeletal disorders, injuries, ill health indicators and physical tension) and stress. (higher tense, strain, exhaustion, lower satisfaction and commitment). According to these scholars, the negative outcomes were mainly caused by an increase of the intensity of the work (generally defined as work pressure, work pace or workload), due JIT and lean tools that constantly reduce buffers and time available for workers to complete their tasks.

Even on the side of the positive work aspects scholars reported a decrease in the autonomy and decision-making in the automotive context. Indeed 9 researches mentioned a decrease in pace control and methods control (Lewchuk et al., 2001; Lewchuk and Robertson, 1997; Yates et al., 2001), autonomy (Bruno and Jordan, 2002; Parker, 2003) and consultation in standard work changes (Babson, 1993).

Just 2 studies in the automotive sector reported positive (Saurin and Ferreira, 2009) or mixed results (Womack et al., 2009). However, the latter, who compared jobs in a lean plant with jobs in a non-lean plant, reported a higher repetitivity and work pace in the lean jobs.

Although theoretically lean should reduce non-value-added activities while concurrently engaging employees, what appears is that in the automotive something went wrong. Clearly some JIT tools have the potential of increasing work intensity, given that the constant reduction of *muda* may enlarge "work density" for workers, reduce potential hidden breaks and increase their interdependence. Conversely, it seems that there has been a lack of employee involvement, as witnessed by the decrease in the autonomy reported by several authors.

In the other manufacturing contexts, the situation appears as more nuanced with just 3 out of 21 studies reporting a predominantly negative effect of lean on well-being (Bouville and Alis, 2014; Brown and O'Rourke, 2007; Jackson and Martin, 1996). Most of the other studies - 11 out of 21 - suggested that lean have both positive and negative effects on well-being, and 6 out of 21 studies proposed that lean has mainly a positive effect on workers. In particular, many authors supported that lean can foster employee involvement increasing workers' influence over work (Håkansson, Dellve, et al., 2017), timing control (Mullarkey et al., 1995), autonomy (Anderson-Connolly et al., 2002; Klein, 1991; Rodríguez et al., 2016), decision making and decision opportunities (Seppala and Klemola, 2004; Sterling and Boxall, 2013), task design participation (Klein, 1991), improvement participation (Angelis et al., 2011; Conti et al., 2006) and boundary control (Cullinane et al., 2014). On the other hand, some of these authors recognized even a potential negative effect of lean as regards work intensification, with studies that reported higher work pace and intensity (Anderson-Connolly et al., 2002; Angelis et al., 2011; Brown and O'Rourke, 2007; Conti et al., 2006; Cullinane et al., 2014; Håkansson, Dellve, et al., 2017), work pressure (Jackson and Martin, 1996; Jackson and Mullarkey, 2000; Sterling and Boxall, 2013; Vidal, 2007a) and increase of workload (Anderson-Connolly et al., 2002; Nikolou-Walker and Lavery, 2009; Seppala and Klemola, 2004).

As for the impact of lean in services, the situation is more optimistic with 7 out of 17 studies that reported mainly a positive effect and 5 out of 17 studies that reported a mixed effect or no change on well-being (Figure 8). Just 3 studies suggested a mainly negative effect on workers' conditions (other 2 studies provided unclear indication). However, even in the service field, it emerges that lean may intensify working conditions with many authors that suggested that work pace and work pressure can increase (Carter et al., 2013, 2017; Dellve et al., 2015; Drotz and Poksinska, 2014; Sprigg and Jackson, 2006; Stanton et al., 2014). As regards autonomy, it is possible to treat healthcare separately from other services. Authors that investigated lean healthcare applications reported an increase in autonomy (Dellve et al., 2015; Drotz and Poksinska, 2014; Ulhassan et al., 2014) in terms of increased influence on their job design, responsibility and decision-making thanks for example to decentralized teams and kaizen improvements events. In other service contexts however, scholars observed a reduction of autonomy due to lean application (Carter et al., 2013; de Haan et al., 2012; Schultz et al., 1998; Sprigg and Jackson, 2006). In this sense lean in healthcare, possibly due to the intrinsic nature of the jobs that cannot be entirely standardized, seems to positively affect the working conditions in comparison to other more routinized services (e.g., call centers or public administration).

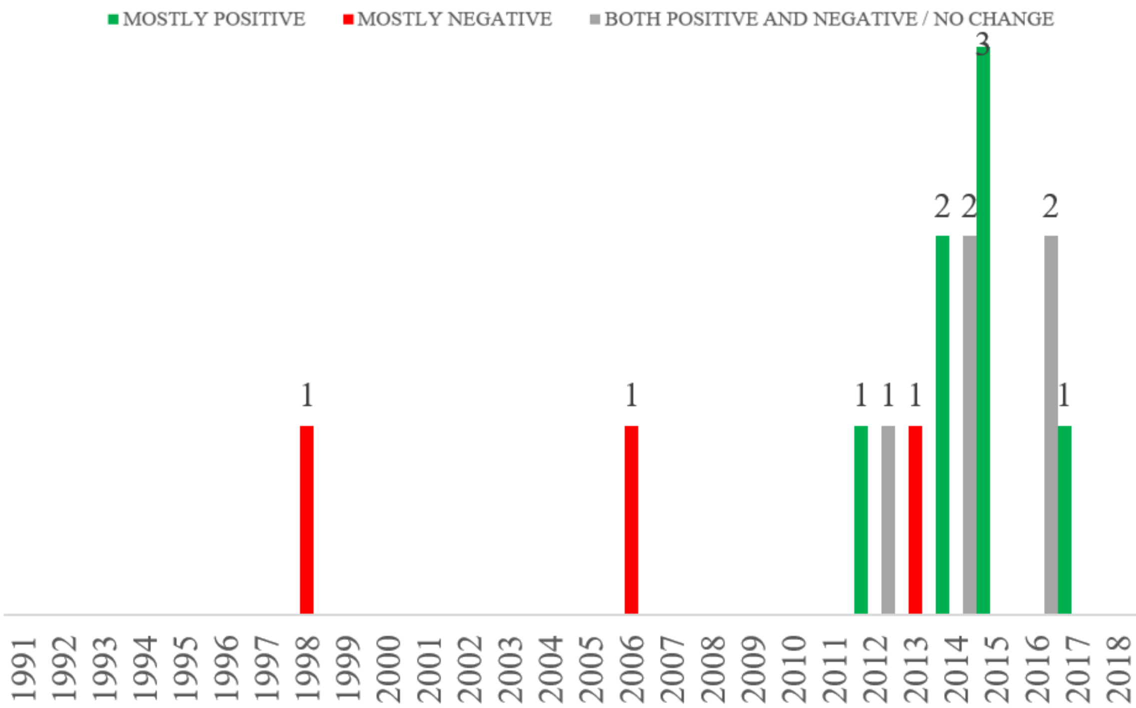

*Figure 8 Researches conducted in **service sector**, divided per overall effect of lean and year of publication*
Note: 2 papers have been excluded from the picture due to lack or unclear information on the overall effect of lean

Table 6 summarizes the results on the overall effect of lean for automotive, other manufacturing, healthcare and other services.

	Specific industry	Automotive	Other manufacturing	Healthcare	Other services
Overall reported effect	+	1 (8,3%)	6 (26,1%)	6 (60,0%)	1 (14,3%)
	+/- or =	1 (8,3%)	12 (52,2%)	3 (30,0%)	2 (28,6%)
	-	10 (83,3%)	3 (13,0%)	0 (0,0%)	3 (42,9%)
	Unclear	0 (0%)	2 (8,7%)	1 (10,0%)	1 (14,3%)
Total (%)		12 (100%)	23 (100%)	10 .(100%)	7 (100%)

Table 6 Empirical studies divided for the specific sector and the main reported effect of lean on employee well-being
Note: 4 papers have been excluded from the picture due to lack or unclear information on the overall effect of lean. 2 theoretical studies have not been included

2.3.2.3. Contrasting Results: the Role of Different Theoretical Perspectives

Not only the context seems to affect the impact of lean on employee well-being, but also the theoretical lens utilized by the scholars.

One striking result is depicted in Figure 9 where the considered publications are divided according to the reported effect of lean and the journal topic. The picture highlights that specific fields of research reported mainly positive or negative results.

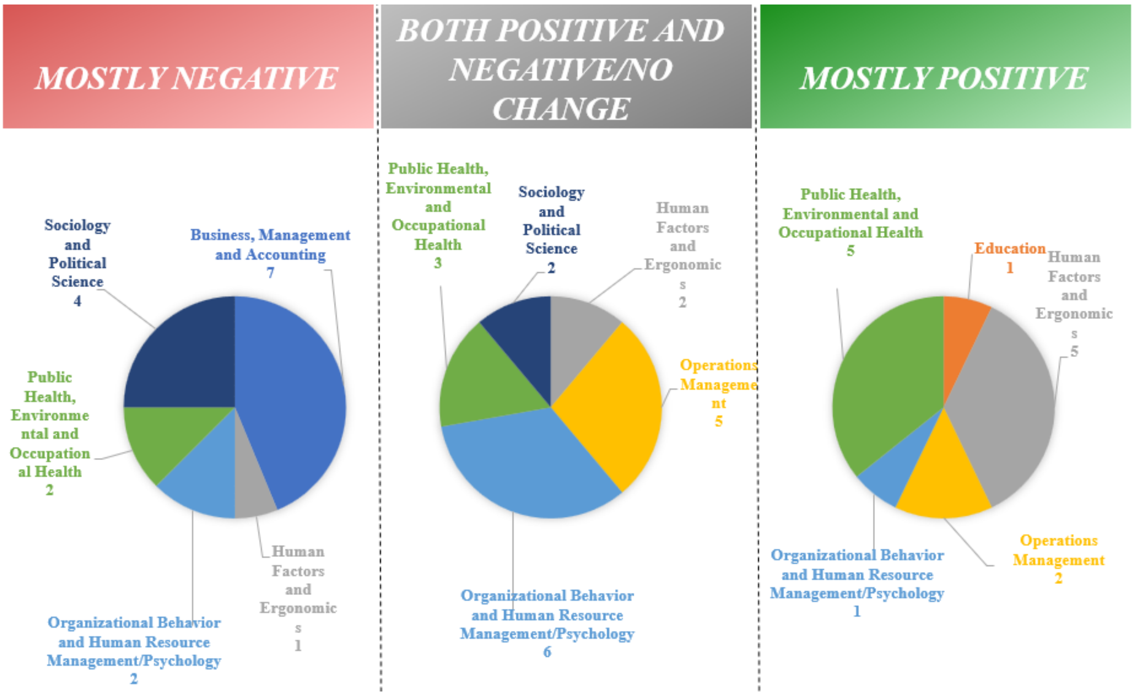

Figure 9 Publications divided per reported effect of lean and field of publication.

For example, scholars publishing in "Sociology and Political Science" journals predominantly reported a negative effect of lean on well-being. This can be partially related to the theoretical lens of the Marxist labour theory they had adopted (Vidal, 2007a). Indeed, according to this theory, lean cannot dissolve the intrinsic contrast between capital and class, being considered as another way to effectively extract labour from workers, through new labels such as "employee involvement" and "value for the customer". In this vein, it is worth to mention the description of the labour process under JIT conditions provided by Conti and Warner (1993) in an early contribution to the topic and not included in this review. They described the JIT working conditions as "contradictory" with "employees working four hours a month in a very non-Taylorist manner to make their work for the rest of the month even more Taylor-like." (Conti and Warner, 1993, p. 39). Rephrasing the words of Conti and Warner and according to this stream of literature, the employee involvement becomes a way to extract more work from blue collars, giving them the illusion of controlling their own work.

On the other hand, scholars belonging to "Operations Management" tended to assume a more positive perspective on the phenomenon. There are no studies published in OM journals that reported mainly negative effects of lean on well-being. In this sense, it appears that OM literature has been more indulgent on lean, emphasizing even the positive aspects for workers. Although all the studies claimed to be rigorous and scientific, it is possible that the inheritance and influence of seminal OM studies on lean (Sugimori et al., 1977; Womack et al., 1990) - that favoured the success of the OM community - may have influenced scholars' perspective. It must not be forgotten that lean is one of the most successful managerial approaches that appeared in OM and has spread in many different fields.

2.3.2.4. Reported Effect of different Lean Bundles on Employee Well-being

In order to further investigate the impact of lean on well-being, the included papers were scanned with the aim of searching for indications on the effect of the different lean aspects. In agreement with Shah and Ward operationalization of lean (2003) in four bundles - JIT, TPM, TQM and HRM - Table 7 shows the classification of papers based on the reported effect of the abovementioned bundles, divided per sector (automotive, other manufacturing and services).

	Industry	Automotive	Other manufacturing	Services
JIT Effect	+	1	3	1
	+/-	-	3	3
	-	10	12	2
TPM Effect	+	-	2	-
	+/-	-	2	-
	-	-	-	-
TQM Effect	+	2	5	-
	+/-	-	2	2
	-	7	2	3
HRM Effect	+	1	11	3
	+/-	-	2	2
	-	2	2	-

Table 7 Classification of papers reporting information on specific lean bundles effects

As regards JIT bundle, the table clearly shows that authors agreed to recognize JIT as a potentially negative element of lean, regardless the context of implementation. In manufacturing as well as in services, the applications of JIT elements such as the Flow principle and the constant *muda* reduction, can indeed increase the work pace perceived by the employees since slack of resources (i.e., extra resources maintained in the organization such as time and inventory (de Treville and Antonakis, 2006)) are constantly removed from the processes while workers are asked to manage the same tasks (Anderson-Connolly et al., 2002; Conti et al., 2006; Jackson and Mullarkey, 2000; Lewchuk and Robertson, 1996; Saurin and Ferreira, 2009; Womack et al., 2009). In addition to work pace, JIT has been associated with higher degrees of interdependence among workers (Cullinane et al., 2014; Klein, 1991). The constant reduction of in-process decoupling inventories (WIP) pushes workers to be more dependent and synchronized with each other, with eventual delays in one process that may affect even previous and following processes. Such situation may expose workers to potentially more stressful conditions. It is interesting to highlight that the constant pressure put on workers by JIT together with *muda* reduction is generally considered as an intrinsic element of lean. As mentioned by de Treville and Antonakis (2006), JIT is intended to push employees to find always better solution to increase productivity, in agreement with Ohno's idea that scarcity of resources may result in a creative tension. It is famous the story of Ohno and his "raids" in the shop floor, looking for kanban to remove (Conti and Gill, 1998).

JIT can be even connected with positive work characteristics. Considering concepts such as inventory reduction and equipment layout to foster flow, it is possible to argue that employees have better feedback on their performance (since there is no buffer that cause a delay between a potential quality problem and its detection), better visibility on their work outcomes and their individual contribution to the overall manufact or service. These positive job aspects might be positively affected by JIT tools, despite the lack of empirical studies supporting this claim (de Treville and Antonakis, 2006).

Concerning TPM bundle, there is an absence of studies that investigated the impact of TPM on employee well-being. Just few researches mentioned aspects related to predictive maintenance

(Cullinane et al., 2014, 2017; Klein, 1991; Longoni et al., 2013). On the positive side, they recognized that TPM application may lead to higher autonomy (since workers are responsible even for the maintenance routines), higher skill variety due the knowledge they need to accomplish these tasks, and less repetitivity of the work. On the negative side, it has been argued that TPM can increase responsibility and accountability of workers since they have to manage capital-intensive assets and they may be blamed in case of breakdown.

With respect to TQM, results are mixed. In the automotive sector, the application of TQM tools (such as work standardization and SPC) was associated with worse working conditions due to a reduction of experienced autonomy and an increase of management control over workers (Lewchuk and Robertson, 1996, 1997; Parker, 2003). Indeed, as argued by theoretical studies (de Treville et al., 2005; de Treville and Antonakis, 2006) standard operating procedures have the potential of reducing choice autonomy – i.e., autonomy related to freedom as regards procedures and timing (de Treville and Antonakis, 2006). In addition, quality control tools, when implemented without proper employee participation and information sharing, may be perceived as forms utilized by the management to exercise tighter control on workers. Moreover, some authors argued that the introduction of quality related tasks further intensified the work (Koukoulaki, 2014; de Treville and Antonakis, 2006), strongly criticizing the idea proposed by Womack and Jones (1990), that supported that lean means working smarter rather than harder. Indeed, when control tasks are transferred to workers without a properly adjustment of their standard times, they may experience an increase in the workload. Additionally, quality related tasks may increase employee accountability and foster a “blame culture” in the same ways as mentioned for TPM (Conti et al., 2006). On the opposite side, mostly outside the automotive industry, quality management tools were connected even to better working conditions. It has been argued that quality tools and quality task assignment to workers, can foster positive work characteristics such as feedback, thanks to more clear quality standards and visual quality control charts, and skill variety, since workers need a broader set of skills to manage new quality-related tasks.

As concerns HRM bundle, most of the literature recognized the positive impact of employee-related practices on well-being. Firstly, tools such as suggestion programs, the creation of groups for problem-solving and continuous improvement, self-managed teams in the shop floor, are recognized to foster higher levels of responsible autonomy (i.e., increase of accountability arising from authority decentralization and participation in decision making - de Treville and Antonakis, 2006) and new knowledge to workers on the organizational processes (Angelis et al., 2011; Cullinane et al., 2014; Saurin and Ferreira, 2009; Stanton et al., 2014). Even other soft tools such as employee cross-training, job rotation and lean training are associated with higher skill variety and thus higher employee well-being. On the other hand, other authors recognized a negative effect of HR bundle on involved employees (Babson, 1993; Bouville and Alis, 2014; Parker, 2003; Vidal, 2007a). Indeed, as suggested by Conti and Warner (1993), employee involvement may also act as an intensification element through which production workers have the possibility (true or illusory is still under discussion - (Jones et al., 2013)) to modify their work environment in a very non-Tayloristic way, but just to make their own daily tasks even more Tayloristic and denser. Moreover, as mentioned by Vidal (2007a), employee involvement may not be of interest for all workers, with some of them that might not want to participate and gain extra responsibility.

Among the reported researches in Table 7, just few of them (Angelis et al., 2011; Bouville and Alis, 2014; Conti et al., 2006; Cullinane et al., 2014; Holden et al., 2015; Sprigg and Jackson, 2006) utilized specific quantitative measures in order quantify the perceived implementation or participation on different lean tools (JIT, TPM, TQM or HRM), linking it to well-being measures. The majority of the other studies utilized qualitative methods in order to characterize the degree of lean implementation.

2.3.2.5. The Role of Implementation Strategy

Considering the positive role of HRM practices in affecting employee well-being, I further investigated the role of the employee involvement during lean implementation. The included researches were divided according to the reported role of the employees during lean implementation and the overall effect of lean. In Table 8 results are reported.

	N° ART. REPORTING A POSITIVE EFFECT	**N° ART. REPORTING A NEGATIVE EFFECT**
BOTTOM UP APPROACH - HIGH EMPLOYEE INVOLVEMENT	6	3
MIXED APPROACH	4	1
TOP DOWN APPROACH - LOW EMPLOYEE INVOLVEMENT	1	7
Not reported/not clear	3	4

Table 8 Articles divided based on the reported overall effect of lean on well-being and the reported degree of employee involvement in lean implementation

What is interesting about the table is that the employee involvement in lean implementation seems to play a role in the overall effect of lean as reported by the researchers. Indeed, it appears that the higher the degree of employee participation and information sharing during lean tool application is, the more positive the reported effect of lean on well-being is. To a certain degree, this table supports the critics, generally raised by lean supporters, that those studies stating a negative effect of lean on well-being generally considered ill-implementation contexts. In these contexts, significant attention was directed towards hard tools, overlooking soft tools and employee involvement, considered as the heart of the "Respect for people" principle of the TPS (Sugimori et al., 1977).

2.3.3. Psychological Perspectives on the Impact of Lean on Employee Well-being

It is worth deepening the different psychological models that scholars used to understand how and why different lean aspects may affect employee well-being. From the analysed studies it appears that three different theoretical perspectives have been adopted: the Job Characteristics Model, the Job

Demand-Control-(Support) Model and the Job Demands-Resources Model. In this section these different theoretical perspectives are briefly presented, with a focus on relevant lean-well-being studies.

2.3.3.1. The Job Characteristics Model

The Job Characteristics Model (JCM) has been one of the oldest and most famous psychological models adopted for studying the impact of lean on well-being. Firstly proposed by Hackman and Oldham (1976), the JCM prescribes that 5 core job characteristics (variety, autonomy, feedback, task significance and task identity) increase intrinsic motivation, work performance, satisfaction and reduce absenteeism and turnover. This relationship between work characteristics and outcomes is supposed to be mediated by specific psychological states of experienced meaningfulness, responsibility for the outcomes and knowledge of the results.

As regards lean, the JCM has been adopted by 4 studies, both in theoretical and empirical researches (Drotz and Poksinska, 2014; de Haan et al., 2012; Rodríguez et al., 2016; de Treville and Antonakis, 2006). However, the model was supposed to have some critical flaws to explain intrinsic motivation under lean, and was extended by de Treville and Antonakis (2006) that furtherly introduced work facilitation (i.e., removal of the obstacles that hinder employee performance and the provision of resources that are instrumental for work goals achievement) as a core job characteristics of lean, and the split of autonomy in two distinct work characteristics: choice autonomy and responsible autonomy (already mentioned above). For de Treville and Antonakis lean, when adopted properly, has the potential to improve the employee intrinsic motivation, considered as measure of employee well-being, increasing skill variety, task identity, feedback, responsible autonomy and work facilitation. They indeed recognized that when there is an excess of leanness, with too much emphasis on *muda* reduction without employee participation, responsible autonomy, skill variety and work facilitation are low and workers may be harmed by lean application.

Apart for the theoretical research of de Treville and Antonakis (2006), the other studies offer very limited empirical evidence as regards the positive effect of lean on work characteristics. Rodriguez (2016), in a simulation game that mimic lean manufacturing introduction, reported an increase in perceived job autonomy and, thus, job satisfaction and operational performance, thanks to lean production introduction. Drotz and Poksinska (2014) in their multiple case study on lean application in 3 healthcare organizations, reported an increase of: skill variety (thanks to problem solving participation), task identity (due to flow and teams application), feedback (thanks to the improvement meetings and visual tools) and responsible autonomy (thanks to teams and improvement projects). They even reported an increase of work pressure due to continuous improvement projects. De Haan et al. (2012) do not provide clear indications on the effect of lean on JCM work characteristics and well-being.

2.3.3.2. The Job Demand-Control-(Support) Model

Another important psychological model adopted by lean-well-being studies is the Job Demand-Control Model. Firstly proposed by Karasek (1979), this model posits that low job control and high job demands are causes of psychological strain, that in the long term brings stress-related illnesses. Moreover, it suggests that control can moderate the effects of demands on strain. Later, the social dimension of support was added to the model resulting in the Job Demand-Control-Support Model (JDCSM - Johnson and Hall, 1988), which added the negative effect of social support on strain and the moderation of social support on the impact of demands on strain.

The JDCSM has been adopted by three studies in the attempt to properly investigate the effect of lean on well-being (Conti et al., 2006; Schouteten and Benders, 2004; Sterling and Boxall, 2013). These studies hypothesized that lean could create the conditions for those active learning jobs, characterized by both high levels of demands but even high level of support and control. According to Karasek, these active learning jobs bring to the highest satisfaction where both significant control and challenges due to high levels of job demands are available. Sterling and Boxall (2013) in their qualitative retrospective case study, reported an increase of control and even pressure due to lean. They even suggested that when trust is *de facto* devolved to workers (a form of social support), workers can benefit it. They thus provide indication of an increase of control, social support and work pressure due to lean, but they did not provide evidence for the moderating effect suggested by the JDCSM. Conti et al. (2006), in their multi-plant survey reported both negative and positive effects of lean, with some lean practices that increased work pressure and some others that foster employee influence and support. Again, they corroborated the idea lean is both positive and negative, increasing control, support and demands, but they did not test the moderating buffering effect of support and control on demand-strain relationship. Schouteten and Benders (2004) in their study in a bike assembly plant concluded that the analysed jobs were all "low strain", and low complexity jobs, characterised by low demands and control. However, no comparison was made with a non-lean production unit and no tests for interactions were performed.

2.3.3.3. The Job Demands-Resources Model[1]

The Job Demands-Resources Model (JDRM) is a specific psychological stress model firstly proposed by Demerouti and Bakker in 2001, drawing upon Lee and Ashforth meta-analysis (1996). It posits two separate but interconnected mechanisms, named motivational and health-impairment processes, that concurrently affect two different well-being measures: work engagement and burnout. This model theories that positive work characteristics - named job resources - mainly affect work engagement (motivational process), whereas negative work characteristics - called job demands - mostly cause burnout (health-impairment process). Moreover, drawing upon the JDCSM and the related body of research, the JDRM supports the interaction between positive and negative work

[1] The Job Demands-Resources Model is further presented and discussed in the following chapter, since it is the main model adopted in developing the hypothesis of the empirical research of this thesis. In this section, after the concise presentation of the model, the studies utilising this model to analyse the lean-well-being relationship are briefly described.

characteristics. In particular, it hypothesizes that job resources can reduce the impact of job demands on burnout, and job demands can increase the positive impact of resources on engagement. In contrast with the JCM and JDCSM, the JDRM is a general model and does not specify *a priori* which specific work characteristics are job demands or job resources. According to its proposers (Bakker and Demerouti, 2017), the JDRM is a flexible model in which the specification of demands and resources must be adapted to the context.

With reference to the impact of lean on employee well-being, the JDRM was adopted in four papers (Cullinane et al., 2014, 2017; Huo and Boxall, 2017; Lindskog et al., 2016). Cullinane et al. (2014) were the first that try to use the JDRM in order to assess the impact of lean on employee well-being. They surveyed 200 employees in a multinational pharmaceutical plant and investigated if lean-related job demands affected exhaustion and lean-related job resources affected engagement, testing also the interaction hypotheses. Their results supported that JDRM can be applied to a lean context, with job resources connected to engagement and demands to exhaustion. However, their interactions results were partial and the link between job demands and job resources with lean appeared to be mainly theoretical. Huo and Boxall (2017) applied the JDRM to a Chinese fast-moving consumer-goods manufacturer, submitting a survey to front line managers. They split job demands in challenging – positively affecting exhaustion and engagement - and hindrance – positively affecting exhaustion and negatively affecting engagement. Again, their results confirmed the applicability of the JDRM in a lean context, in this case to front line managers, adding the further distinction between hindrance and challenge demands. However, they did not test any interaction. The applicability of the JDRM was even confirmed by the second Cullinane et al.'s study (Cullinane et al., 2017) in which they provided additional evidence of the positive effect of lean job resources and negative effect of lean job demands on well-being, introducing also the concept of job crafting. In the healthcare sector, Lindskog et al. (2016) used the JDRM lens in order to study if lean tools in healthcare (standardised work, 5S, visual follow-up boards, and value stream mapping) affect working conditions (i.e., engagement in development, job satisfaction and exhaustion), while considering other job demands and job resources as contextual elements. Their results supported that lean tools can promote employee engagement in development and job satisfaction (while not exhaustion) when sustained by a supportive context characterized by job resources.

Huo and Boxall published a further study (2018) that applied the JDRM in assessing lean and well-being relationship. This study is not included in the current literature review since it has been published very recently, after the completion of the analyses. Nevertheless, in order to give a complete overview of the topic, their results are briefly presented here. In their cross-sectional study involving around 350 production workers in a Chinese fast-moving consumer goods company, they examined the effects of problem-solving demands and lean job resources on engagement and exhaustion, highlighting an interaction between the two aspects. Specifically, they provided pieces of evidence as regards the buffering effect of job resources on the positive impact of problem-solving on exhaustion, and the moderating effect of problem-solving since it can reinforce the effect of job resources on engagement.

2.4. Research Opportunities and Gaps

The literature review analysis of the different contributions in matter of lean and employee well-being allows to discuss all relevant unexplored aspects or elements that deserve further investigation. This review suggests the following paths for future research.

2.4.1. Positive and Negative Elements of Lean

The impact of lean on well-being has not been fully comprehended yet. In the manufacturing context, the older literature tended to recognize the negative effects of lean on well-being, with a major focus on the automotive sector and JIT tools. More recent studies started to adopt a more nuanced perspective, recognizing that lean may even positively affect employee well-being, suggesting that it is important to overtake the simplistic unilateral perspective that lean is either entirely good or entirely bad. In this direction, future research must address better why and in which conditions lean can have a positive effect on employee well-being.

In particular, it is central to understand when negative lean related aspects - mainly those associated with JIT, according to previous literature - can be overcome or offset. It would be interesting to further explore if other lean bundles and practices, such as those related to SLP, can modify the well-being impact of other lean aspects. Previous research provided some clue that JIT tools could particularly damage workers' well-being when human-side tools are overlooked. This was firstly suggested by Parker et al.[1] (1995) in a British automotive study, where they reported a positive impact of lean on well-being when employees were involved and a negative impact of lean when there was no involvement. Longoni et al. (2013) in a qualitative multiple case study, supported that soft lean can reduce the harmful effect of JIT, and suggested a further research need for confirming the claim. Cullinane et al. (2014) quantitatively examined the effect of positive lean aspects and negative lean aspects and their interactions on well-being, but they did not find a significant buffering effect of positive lean aspects (partially linked to soft lean) on the demanding lean aspects-stress relationship. So, this remains an important gap to fill since there is lack of clear quantitative evidence, even considering that managers are often not aware of the negative effect of lean on employees and may focus lean implementation only on harmful JIT tools.

An additional important gap is represented by the effect of problem-solving on employees. In a lean company workers are typically responsible for solving problems during their production tasks in order to foster the flow (MacDuffie, 1995; Womack et al., 1990). Literature in this case does not provide clear indication of the effect of problem-solving on well-being. Some authors reported that, since blue collars have to quickly solve issues when they pop up, they experience incremental pressure (Bouville and Alis, 2014; Jackson and Mullarkey, 2000; Vidal, 2007a). However, they can

[1] The study was published as book chapter and therefore it was not included in the current literature review database.

even experience satisfaction in utilising their personal autonomy and skills to solve problems (MacDuffie, 1995; Womack et al., 1990). Cullinane et al. (2014) reported that problem-solving might be an exhausting element of lean working conditions, in agreement with quantitative findings of Bouville and Alis (2014) and Jackson and Mullarkey (2000). On the contrary Huo and Boxall (2018) reported a positive link between experienced problem-solving and engagement. Whether problem-solving is a stressing or engaging element remains unclear.

Even the effects of other lean tools as those related to TPM deserve further investigation. Only few studies (Cullinane et al., 2014, 2017; Klein, 1991; Longoni et al., 2013) reported an impact of TPM on well-being with authors recognizing a positive impact of TPM due to the extra autonomy and variety provided to workers, together with the capacity to reduce stressful events such as equipment breakdowns. However, whether TPM could even cause extra-stress on workers because of the increased number of tasks they have to perform or the extra responsibility they have in managing expensive equipment, remains unclear. Considering TQM, the situation is more defined with some aspects of TQM associated with worse working conditions (e.g., standard procedures may reduce autonomy) and some others with better working conditions (e.g., visual charts can provide valuable feedback on the job).

2.4.2. Elements Potentially Affecting the Effect of Lean on Well-Being

Thinking of other aspects that may affect the impact of lean on employee well-being, what emerges is the need for further scientific investigation.

This literature review clearly shows that one key contingency is the implementation strategy a company adopts (top down/low involvement vs. bottom up/high involvement). This aspect is clearly connected with the previous point regarding the role of SLP (that are exactly those related to employee involvement) in affecting the impact of lean on well-being. Further studies should focus on this aspect as to clearly and quantitatively prove that a bottom-up approach, based on involvement of workers, is more likely to foster better (or less bad) working conditions in comparison to a top down approach.

Even other contingencies must be addressed in order to understand if they may play a role in affecting lean-well-being relationship. Most interesting factors that need further research are:

- Culture: the way people perceive specific aspects of lean as stressing or engaging may be related to their national or their organizational culture. The orientation towards change in the organization and the values that people share may affect their perception of lean introduction (Danese et al., 2017).
- Production process and variety-volume mix: since lean is both associated to standardization and variability reduction (that should reduce autonomy), and to kaizen and employee involvement (that should increase autonomy – see for example the distinction between choice and responsible autonomy propose by de Treville and Antonakis (2006)), it is possible that the actual pre-lean degree of autonomy experienced by workers, could be a crucial factor in determining the effect of lean on well-being. As a medical treatment can affect in different ways different patients according to their pre-treatment conditions, so lean effect can vary based on the company pre-lean conditions. Indeed, if a worker is a craftsman employed in a low volume - high variety production context, it is possible that lean is perceived mainly as a standardization of their work and that involvement in continuous improvement is not able to compensate the loss in autonomy due to standardization. On the other hand, if a worker is employed in a high volume – low variety assembly line, extra-autonomy provided by employee involvement, suggestion, improvement and problem-solving teams may lead to better global conditions, whereas a further standardization of their task may be not perceived as harmful.
- Leadership: in the lean field many authors reported that a specific leadership style called lean leadership, is a crucial aspect for a correct lean application (Liker and Convis, 2011). This aspect has been barely analysed in relation to the effect of lean on well-being (Bäckström and

Ingelsson, 2015) and deserves major attention. Indeed, an engaging leadership is recognized as an important positive work characteristics that may shape perception of workers of their working conditions and finally their well-being (Schaufeli, 2015).

- Psychological Safety: another aspect that may shape the employee experience of lean is the degree of psychological safety (the belief that it is safe to take an interpersonal risk - Edmondson, 1999). Indeed, if workers are pushed to participate in change and problem-solving in a psychologically unsafe environment where they may be blamed for their failures, it is likely that lean tools could be perceived as stressing work characteristics. No studies quantitively assess the role of psychological safety in changing employee experience of lean and finally their well-being.

2.4.3. Other Gaps

An additional interesting gap is the lack of studies focused on other aspects of the working life rather than the most common outcomes generally analysed such as satisfaction, commitment, stress, engagement and exhaustion. Possible future studies could inquiry the impact of lean on other outcomes related to well-being at work. Some examples could be relational coordination (Carmeli and Gittell, 2009; Gittell, 2001), job crafting (Cullinane et al., 2017; Tims et al., 2013) and positive psychological capital (Luthans and Youssef, 2004).

A further important gap that it is worth mentioning is that only few studies adopted a clear psychological model that incorporated a broad set of negative and positive aspects and related them to workers' well-being. It is crucial for future research that intend to explore the effect of lean on well-being to draw upon existing organizational psychology literature and select a proper stress theory and the underlying model, in order to add soundness to the study. It is even interesting to notice that no studies applied the effort-reward imbalance model (ERI) for assessing the impact of lean on stress (Siegrist, 1996).

Finally, a last minor but relevant gap is that no studies among those included in the review investigated the impact of specific lean applications such as lean product development or lean accounting on employee well-being. In the case of lean product development for example, it is likely that the application of lean principles and tools (e.g., flow and visual management) to new product development processes significantly modifies the work environment and even the work characteristics and thus the well-being of involved employees.

2.5. Research Question

Given the previously reported gaps, the empirical research presented in this thesis is intended to provide further evidence on the impact of lean on well-being, with a specific focus on lean manufacturing. This research aims to address two major gaps reported above. The first one is that related to the potential interaction of SLP and JIT, given the untested claim that soft lean practices can reduce the negative impact of JIT on employee well-being. The second gap regards the unclear role of problem-solving. Indeed, this work intends to provide further evidence on the role of problem-solving in affecting well-being. Moreover, the previous gaps will be addressed through a specific psychological model, the Job Demands-Resources Model as theoretical basis for the analysis. This addresses the further issue reported above that few studies properly adopt a clear psychological model. Indeed, a specific model can strength the research on lean and well-being.

Therefore, in order to contribute to the debate on lean and well-being through addressing these gaps, a general research question has been developed:

RQ: In a lean company, how do negative and positive lean-related job aspects (i.e., those related to SLP, JIT and problem-solving) influence employee well-being in terms of work engagement and exhaustion?

In the next chapter several hypotheses based on this research question are developed and investigated in an empirical study.

3. Soft Lean Practices and Employee Well-Being: an Empirical Study

3.1. Overview of the Chapter

This chapter describes the empirical research conducted in an Italian plant of an international home appliance manufacturer. Here, the effects of different lean-related job aspects on employee well-being are inquired. So, starting from the research question reported in the last part of the previous chapter, section two of the current chapter addresses the available literature on lean and employee well-being with a focus on the JDRM (Job Demands-Resources Model), and it develops several hypotheses as regards the effect of different lean-related job aspects and their interactions on work engagement and exhaustion. The third section reports the adopted methodology including: the description of the selected company, the data collection procedure, the sample characteristics, the scales and measurement models utilized to check goodness of fit. Finally, the fourth section reports the statistical models utilized to test the hypotheses and figures depicting the most relevant results.

3.2. Hypotheses Development

Starting from the research question on how negative and positive lean-related job aspects influence work engagement and exhaustion of employees in a lean company, several hypotheses have been developed based on JDRM and the lean and employee well-being literature. However, before proceeding with the hypotheses presentation it is crucial to have a deeper overview of the JDRM already briefly presented in section 2.3.3.3, as it is at the core of this research.

3.2.1. The Job Demands-Resources Model

An interesting and relatively novel psychological model that may help to shed light on the contradictory results available in literature is the JDRM (Bakker and Demerouti, 2017; Demerouti et al., 2001).

The JDRM proposes a dual-path model in which two mechanisms, the health-impairment one - focused on strain and burnout- and the motivation one - focused on engagement - are responsible for employee well-being at work.

According to this model, the health impairment mechanism is activated by those job-related aspects (physical, social or organizational), named job demands, that require a sustained effort (physical or mental) and that are associated with a cost for the worker, either physiological or psychological. Job demands are considered as exhausting job aspects that may lead to burnout and eventually to ill health. Burnout is here defined as a syndrome of chronic exhaustion, a cynical negative attitude regarding work and a reduced professional efficacy (Maslach et al., 2001; Schaufeli et al., 2001; Schaufeli and Taris, 2005). It is generally considered as the predominant outcome of the health impairment process (even though some exceptions are available, e.g., Hansez and Chmiel, 2010). Despite its multidimensional nature, all three burnout dimensions (exhaustion, cynicism and reduced professional efficacy) are barely included in JDRM researches. Many studies generally include only the exhaustion dimension (e.g. Demerouti et al., 2001; Huo and Boxall, 2018), defined "as intensive physical, affective and cognitive strain, as a long-term consequence of prolonged exposure to work stressors"(Demerouti et al., 2000, p. 455). JDRM literature provided ample evidence that job demands are the major predictor of exhaustion (Bakker and Demerouti, 2017; Van Veldhoven et al., 2005). Moreover, burnout, and particularly exhaustion, in turn have been associated with physical and mental health issues such as physical pain, actual and future depression, memory impairment and sleep disturbance (Hakanen et al., 2008; Peterson et al., 2008).

In contrast with the health impairment process, the motivational mechanism considers that positive physical, psychological, social or organizational job aspects, called job resources, have a motivational impact and increase work engagement. According to their definition, the job resources increase engagement since they are functional to accomplish the job, decrease demands and their costs, and foster individual growth and development. Work engagement is generally defined as a fulfilling, affective and positive motivational status of well-being at work, and it is the most utilised outcome of the JDRM motivational process (exceptions exist e.g. Bakker et al., 2003; Hansez and Chmiel, 2010; Tims et al., 2013). Even work engagement is multi-dimensional construct composed concurrently by three different states: vigor (feeling full of energy), dedication (being enthusiastic about work content), and absorption (being immersed in work activities). Seldom scholars include all 3 dimensions of work engagement in their job demands-resources models, generally preferring just vigor and/or dedication.

It is worth observing that, dissimilarly to other popular work-related stress theories like the job demands-support-control model (Karasek, 1979) or the job characteristics model (Hackman and Oldham, 1980), the JDRM does not limit *ex ante* the analysis to a specific set of work characteristics. It adopts a contingent standpoint supporting that any demand and any resource may affect employee health and well-being and depending on the assessed context, the specific work characteristics may appear as resources in one context and as demands in another.

In addition to the two distinct mechanisms, job demands-resources theory hypothesizes that there is an interaction between resources and demands, that reciprocally modify their impact on burnout and work engagement respectively.

Rooted in the definition of resources, indeed, there is the assumption that job resources can reduce (i.e., buffer) the impact of job demands on strain. This is consistent with the previous job demand-control-support theory (Karasek, 1979) but extends this buffering effect to a broader set of job resources and job demands (not just the reducing effect of autonomy on work overload-job stress relation as hypothesized by Karasek). Coherently with this perspective, Kahn and Byosiere argued that properties of the work situation may buffer the effects of a stressor on strain, eventually reducing their health- damaging consequences (1992, p. 622).

Empirical evidence provided support for this buffering effect (Bakker et al., 2005; Xanthopoulou et al., 2007). An example is the large sample study (12.000 employees) performed by

Bakker et al. (2010). They investigated a large set of demands and resources and they showed that 88% of all possible interactions between job demands and resources are significant. They concluded that employees can draw upon large a set of resources in helping them to cope with demanding work characteristics.

A further interaction is hypothesized between resources and demands when job resources-work engagement link is considered. Specifically, the JDRM hypothesises that job resources would be more effective on work engagement in conditions of higher demands. This is in line with Hobfoll's theory of conservation of resources (2002) that suggests that extra resources gain salience in more demanding working conditions. Empirical studies providing pieces of evidence on this aspect can be found in literature (Bakker et al., 2007; Cullinane et al., 2014; Hakanen et al., 2006).

Recently the JDRM has been updated, with some authors suggesting that job demands may take part not only in the health-impairment process but event in the motivational mechanism. LePine et al. (2005) firstly proposed an important distinction between two forms of demands: challenge and hindrance job demands (van den Broeck et al., 2010; Crawford et al., 2010). Both types of demands positively affect burnout (thus exhaustion, in agreement with JDRM health impairment mechanism), but job demands that may be appraised as challenging are positively related to engagement, whilst hindrance demands are negatively related to engagement. Again, a clear distinction here depends on the context and the specific employee appraisal mechanisms. What may be considered as engaging in one job, could be exhausting in another one (Bakker and Demerouti, 2017; Bakker and Sanz-Vergel, 2013).

Even the direct impact of job resources on burnout has been subject of discussion. Recently, reviews on the JDRM provided evidences on a weak direct impact of job resources on exhaustion, supporting that resources have the potential to reduce burnout (Bakker and Demerouti, 2017; van den Broeck et al., 2010; Crawford et al., 2010).

3.2.2. Lean and the Job Demands-Resources Model

3.2.2.1. Previous Studies on Lean and JDRM: recall of findings, limitations and gaps

As mentioned in section 2.3.3.3, two first relevant researches tried to investigate the complex phenomenon of lean production impact on production workers' well-being through the lens of the job demands-resources model (Cullinane et al., 2014; Huo and Boxall, 2018). A deeper view on these researches and their limits is provided here, with a focus in important open issues already mentioned in section 2.4.1.

Cullinane et al. (2014) firstly applied the JDRM in a lean environment, investigating the impact of lean-related demands and resources on well-being. The researchers reported a significant impact of three specific lean job resources (training provision, boundary control and performance feedback) on work engagement (positive) and exhaustion (negative). They also demonstrated the positive effect of four lean-related job demands (production pace, task interdependence, problem-solving and accountability) on exhaustion, though they did not consider the impact of demands on engagement nor distinguish between hindrance or challenging demands. As regards the buffering effects, they reported significant moderating effect of demands on job resources-engagement relationship, but they fail to provide evidence of the buffering role that job resources can play in reducing the impact of lean-related job demands on exhaustion. Despite some interesting results, this study has some limitations. First of all, two of the considered job resources, training provision and performance feedback, are general work characteristics rather than specific lean-related work aspects, with their link with lean that remains merely theoretical. Moreover, aspects such as boundary control (i.e., the extent to which workers participate in activities traditionally performed by supervisor or first-line managers) and feedback, may not represent *per se* a resource for workers. Indeed, in case of so called "ceremonial adoption" of lean , without an adequate continuous improvement infrastructure (coaching sessions, employee suggestions, problem-solving teams, etc.), an excess of feedback or control may be perceived as useless or even negative. In addition, boundary control encompasses a wide variety of distinct lean practices (autonomous maintenance, quality inspection, help in training, autonomous setup and material replenishment, scheduling control), lacking a clear discriminant validity. As regards their analysis, there may be a certain degree of concern on statistical accuracy of their model, being the residual errors of the two outcome variables allowed to correlate[1] (Cole et al., 2007; Hair et al., 2014).

More recently, Huo and Boxall (2018) explored the impact of problem-solving on employee well-being and its interaction with lean job resources (considered here as soft lean practices rather than general job characteristics). They showed how a specific set of lean job resources (i.e. lean training, employee participation and line manager support) may buffer the negative impact of problem-solving, whilst problem-solving may increase job resources positive effect on work engagement. This study confirmed that specific SLP (i.e., lean training, employee participation, line-manager support) may act as positive organizational resources and that SLP may interact with problem-solving demands. However, problem-solving role remained unclear since the direct impact on exhaustion was non-significant in their main model. Nevertheless, they do not investigate other negative job aspects, generally associated with lean such as those strictly related to JIT tools, and they leave room for the investigation of a different set of SLP.

Generally, these two studies offer an important ground for further investigating lean-well-being relationship through the JDRM, with many open points that deserve further research. In particular, the qualitative claim of previous literature, that SLP can reduce the negative effect of other lean elements - such as JIT-related work aspects - remains untested (Hasle et al., 2012; Longoni et al., 2013; Parker et al., 1995; de Treville and Antonakis, 2006) and represents an important gap in the

[1] Regarding the possibility to let two residual errors free to correlate, a discussion is on-going in literature. Generally, scholars tend to consider the inclusion of correlated residuals in structural equation model as a major flaw. Hair et al. (2014, p. 607) said "Allowing these paths to be estimated (freeing them) seriously question the construct validity of the construct" and "although these paths can be freed (covariance permitted) and improve the model fit, doing so violates the assumptions of good measurement". On the other hand, other scholars in the psychology field have recently suggested that in many cases allowing residuals to correlate is acceptable and the non-inclusion of residual correlations that are totally justified on the basis of measurement theory and research design, might generate potentially misleading results (Cole et al., 2007).

research on lean and well–being. Secondly, a further interesting gap is represented by the controversial role of problem-solving in a lean company, with Huo and Boxall (2018) that found a significant positive relationship between problem-solving and work engagement but in general not with employee exhaustion, in contrast with Cullinane et al. (2014).

3.2.2.2. Lean and Job Resources

In lean literature, several SLP have been reported to positively affect employee well-being through specific positive job characteristics (Conti et al., 2006; Cullinane et al., 2014). For instance, the participation of employees in autonomous teams to solve problems or in suggestion programs, are generally connected with higher levels of perceived autonomy and a broader set of acquired skills. In fact, thanks to these elements, workers can obtain new capabilities and experience a new form of autonomy (e.g., suggesting to modify a standard) that would hardly be accessible in a traditional mass production plant. (Anderson-Connolly et al., 2002; Angelis et al., 2011; Conti et al., 2006; Cullinane et al., 2014; Huo and Boxall, 2018; Mullarkey et al., 1995; Parker, 2003; Saurin and Ferreira, 2009; Vidal, 2007b, 2007a). This effect has been clearly explained by de Treville and Antonakis (2006), which reported that a lean genuine implementation favours workers' skill variety and responsible autonomy, that consequently increase motivation and job satisfaction.

Other SLP such as the management presence on the shop-floor, coaching and management leadership for lean are meant to affect other positive work characteristics such as feedback from the job, feedback from the others and work facilitation (Bäckström and Ingelsson, 2015; Drotz and Poksinska, 2014; Håkansson, Holden, et al., 2017; de Treville and Antonakis, 2006). In particular, management contact with the shop floor provides workers with constant feedback on their performance as regards their daily activities as well as their continuous improvement duties. Moreover, it provides support to employees in coping with difficulties and hindrances that prevent them to reach their work goals (i.e. work facilitation, de Treville and Antonakis, 2006). Management leadership for lean and coaching, further push employees to participate in kaizen thanks to "lead-by-example" management effort in lean initiatives, with coaching that gives workers further chances for personal development and changes in their work environment.

In turn, work-related stress literature provides ample theoretical explanation and empirical support that SLP, through the mentioned positive work characteristics, can increase employee well-being (e.g., Hackman and Oldham, 1975; Karasek, 1979). According to the Job Characteristics Model, for example, it is possible to support that SLP - fostering autonomy, skill variety and feedback - can increase the three critical psychological states of experience meaningfulness, responsibility and knowledge of the results, that consequently affect intrinsic motivation and job satisfaction.

On the other hand, previous JDRM studies on lean also included a negative impact of job resources on exhaustion (Cullinane et al., 2014; Huo and Boxall, 2018). This is in line with recent JDRM reviews that recognized a weak but significant capacity of positive job resources to directly reduce experienced burnout (Bakker and Demerouti, 2017; van den Broeck et al., 2010; Crawford et al., 2010), and previous lean studies that reported a negative effect of SLP on stress (Conti et al., 2006; Jackson and Mullarkey, 2000).

Based on the previous arguments, in agreement with the JDRM conceptualization of job resources, it possible to hypothesize that SLP - including small group problem-solving, employee suggestions, shop floor contact with managers, top management lean leadership and coaching - act as organizational job resources, fostering work engagement and reducing exhaustion. Thus, the following hypotheses are proposed:

H1: Soft lean practices are positively related to work engagement.

H2: Soft lean practices are negatively related to exhaustion.

3.2.2.3. Lean and Job Demands

As regards job demands, previous studies reported that JIT elements lead to higher negative work characteristics such as task interdependence and work pace (Adler and Cole, 1993; Jackson and

Mullarkey, 2000; Klein, 1991; Niepce and Molleman, 1996; Vidal, 2007b). Indeed, as mentioned in the previous chapter, the strong focus of just-in-time in reducing stocks and buffers has the potential to intensify the degree of interdependence between workers and consequently damage working conditions. This is because production systems characterized by low levels of inventories imply that workers are more exposed to manufacturing problems being severely synchronized with each other.

In addition, continuous efforts to remove wastes (*muda*) from manufacturing activities can increase the perceived work pace, pushing employees to work faster. Indeed, the available work time to perform a task is meant to be continually reviewed and reduced for the sake of kaizen. What might be caused is an increase of the work pace, the repetitive nature of the job and a reduction of those hidden breaks that workers use as recovery time (Dombrowski et al., 2017; Womack et al., 2009).

Just-in-time negative effects reported by empirical studies, have been further confirmed in the experimental study performed by Schultz et al. (1998). They compared a three-workstation serial process with small buffers to the same workstations organized in parallel. They found that buffer minimization increased interdependence and work pressure to complete the work in time, since workers tried to avoid being the cause of blocking and starving phenomena. It can be easily supposed that this effect is even more exacerbated in real low-buffer operations, where quality and production problems are common on a daily basis, and workers may be pushed to work faster in order to avoid flow-disruptive events.

Considering that workers do not directly participate in JIT tools implementation (i.e., kanban, buffer reduction and flow layout) but generally undergo their impact through these specific work characteristics, it is possible to consider work pace and interdependence as JIT-related work characteristics. In line with the arguments presented above and with organizational psychology literature (Karasek, 1979; Rosen et al., 2010; Wong et al., 2007), it is possible to hypothesize that work pace and interdependence act as JIT-related hindrance job demands (JIT-JD), with a positive effect on exhaustion and a negative effect on engagement. Therefore, the following hypotheses are advanced:

H3: JIT-related job demands (acting as hindrance job demands) are positively related to exhaustion.

H4: JIT-related job demands (acting as hindrance job demands) are negatively related to engagement.

Another work characteristic that has been recognized by literature as a potentially harmful aspect of lean is problem-solving job demands (PS-JD), defined as the degree to which the worker perceives that their job requires unique solutions or ideas, and it reflects an active cognitive requirement of a job (Cullinane et al., 2014).

In their studies on lean plants, MacDuffie (1995) and Jackson et al. (2000) suggested that problem-solving demands may increase due to lean because production employees must regularly solve issues and problems to preserve the production flow. This situation is caused by the buffer protection minimization or removal, that expose workers to production difficulties and complications (related to intrinsic variability of material, human and machine aspects), that employees must avoid or rapidly solve as they pop up on the shop floor.

Considering previous studies on problem-solving, there is no consensus on whether it positively or negatively affect employees. Some of these researches reported a certain degree of concern as regards this job aspect, supporting that problem-solving can increase pressure that in turn negatively affect the employee well-being (Bouville and Alis, 2014; Vidal, 2007a). Some others proposed that problem-solving could be a challenge job demand, thus fostering higher levels of exhaustion and engagement at the same time (Huo and Boxall, 2018). This can be explained considering that problem-solving can even fulfil basic psychological needs like that for competence and autonomy (van den Broeck et al., 2008; Ryan and Deci, 2000).

Considering these positions, it is postulated that that problem-solving job demands may act as a challenge job demands promoting work engagement but even having a potential exhausting effect on workers:

H5: Problem-solving job demands (acting as challenge job demands) are positively related to exhaustion.

H6: Problem-solving job demands (acting as challenge job demands) are positively related to work engagement.

3.2.2.4. Interaction between Job Demands and Job Resources

In agreement with the JDRM, it is possible to postulate specific interactions between job demands and SLP, considered here as job resources.

I posit that JIT-related job demands and problem-solving job demands impact on exhaustion is mitigated by SLP, acting as job resources. This idea is in line with previous qualitative findings suggesting that soft lean may mitigate the negative effect of other lean practices such as JIT (Hasle et al., 2012; Longoni et al., 2013; Parker et al., 1995). Moreover, I hypothesize that SLPs have a higher impact for those workers experiencing more demanding conditions, either in terms of JIT or problem-solving, as the JDRM assumes that job resources are more important for individuals exposed to more demanding conditions. On this basis, the following hypotheses are advanced:

H7 (a and b): Soft lean practices reduce the positive impact of JIT-related job demands (a) and problem-solving job demands (b) on exhaustion.

H8 (a and b): JIT- related job demands (a) and problem-solving job demands (b) increase the positive impact of soft lean practices on engagement.

Figure 10 depicts the framework of this research with all the proposed hypotheses derived from literature.

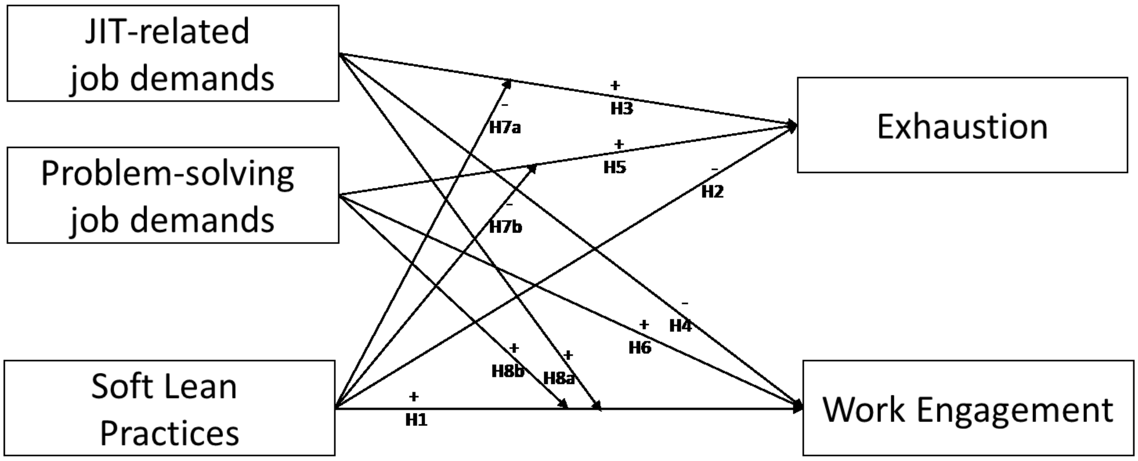

Figure 10 Theoretical model

3.3. Methodology

3.3.1. Context

This study was conducted in an Italian subsidiary plant of a multinational home appliance manufacturer. In the investigated plant, 530 production workers are employed in a facility that manufactures more than 500.000 dishwashers per year. Lean manufacturing was introduced in 2006 as part of the group operations strategy. The investigated company adopted a company-specific production system (XPS - Netland, 2012), inspired by the Toyota Production System, such as other multinational manufacturing corporations. Their production system was based on three main areas: (1) cultural change related to leadership, people development and operational excellence; (2) process improvement that regards flow, process mapping and quality, and (3) stability that addresses safety, visual aspects and waste reduction.

In the investigated plant, dishwashers are produced through two different production steps: sheet-metal stamping, and assembly. These phases occur in two separate areas named "Technological" and "Assembly" respectively. In the first area, dishwasher frame bars and doors are realized through cutting, stamping and welding. The process starts from raw material (stainless steel coils) and is completed with the creation of the entire dishwasher finished frame. All these production steps are strongly automatized, and production employees must perform tasks related to set-up for changes in production mix, machine loading / unloading, material handling, equipment supervision and quality checks. In the second production unit, the product is assembled along four distinct assembly lines characterized by a mixed-model orientation. In the lines production employees perform electrical and mechanical manual assembly tasks and quality control activities. All material that has to be installed on the frame, is provided just-in-time alongside the assembly stations, by tow-trains. The company has worked on inventory minimization and reduction, in agreement with lean principles. In particular, in assembly lines workers have a specific standard time to perform the assigned tasks, in order to accept with no delay the sub-assembled part from the preceding assembly station and provide with no delay the next worker with the needed part. It is relevant to highlight that there is a strong interdependence among production employees since they are strictly synchronized in the assembly lines. However, this interdependence is partially reduced by few inventory buffers, specifically placed in areas where there is higher variability of production tasks (in order to avoid disruption events). Even if lean managers and production engineers systematically applied line balancing principles, they reported that there is a significant amount of variability of the workload between different assembly line positions, due to ineradicable products and process characteristics.

The investigated plant was chosen for the research following specific guidelines in order to increase research soundness and generalisability. To begin with, the plant adopted a specific lean production system in line with many other companies. Second, in the plant lean had been adopted in a comprehensive way (all lean bundles) and the plant had gained a solid reputation as regards lean, at national and international level. Indeed, among the production facilities belonging to the group, the considered one is a top plant, with lean implementation level certified by the internal auditing system. Moreover, plant lean managers have been considered as experts in their field, teaching lean and presenting the company case study in Italian business masters and seminars. Furthermore, the considered plant has not been involved in any important change such as acquisitions or merges during the last decade, and the group has a strong financial position and stability.

Lean implementation level was checked through company audits, interviews with lean and human resource managers, following a protocol based on lean dimensions proposed by Shah and Ward's (2007), and through plant visits. The primary applied lean tools included just-in-time (just-int-time inbound replenishment, just-in-time delivery from suppliers, inventory minimization, flow orientation driven by customer demand, balancing of lines and tasks, set-up time reduction), total quality management (SPC, workplace management through 5S, standard works, real-time in-process feedback), total preventative maintenance (autonomous maintenance). In addition, visual management is widely implemented through paper-based and electronic-based visual boards located in the shop-floor close to assembly lines and machines.

Regarding soft lean practices, the company has extensively invested in involving and supporting workers in lean adoption. First, managers belonging to middle and high levels have been trained on lean principles and tools. Moreover, they have been and still are stimulated to actually spend as much time as possible with workers on the shop floor, in line with lean leadership values (e.g., *genchi genbutsu*, "lead-by-example"). Secondly, the technical staff is located nearby production processes to support employees in case of operative problems. Third, multifunctional teams have been adopted and production workers are usually included in these groups. These teams have been focused on problem-solving of production and quality issues and kaizen of products and processes. Fourth, some managers personally participate in multifunctional groups' activities, and some of them are responsible for specific visual management and lean routines. For example, daily, production managers complete a safety audit (connected with a safety KPI visually exhibited on the shop floor), and weekly and yearly awards are voted by managers to the best lean improvement suggestion and projects. Fifth, the company has adopted coaching as a specific lean tool, including it as part of their production system (Rother, 2009). All managers (low, middle and high) were adequately trained in coaching routines in order to develop leadership and problem-solving capabilities in management and subordinates. Through formally established meetings, specific weekly routines based on Deming cycle, have been adopted at all levels of the organization, including shop floor employees-production supervisors' relations. Sixth, a suggestion system is in place with workers stimulated to participate and provide personal contributions and ideas to improve production processes, products and work environment. A visual management system is available in the production environment exhibiting the number of accepted and implemented suggestions per period, and connected savings. As mentioned above, on a weekly basis the best idea is awarded and celebrated by a member of the top management, in front of the colleagues.

In addition to these practices, all production employees have received a lean basic training as regards philosophy, principles and tools. Moreover, all production workers rotate in their production sub-unit among different roles during their shift (at a fixed rate) to reduce health-related issues (e.g., repetitive strain injury risk) and to improve skills redundancy in the plant.

Despite the broad application at plant level of these human-related aspects, change agents recognize a certain variability in the perception of these lean soft practices among employees, due to a variable implementation level and a heterogeneous workforce. involvement. Moreover, individual workers might build different meanings of organizational practices based on their individual experiences, so, perception of SLP may depend on specific situations they have lived at work as well as their individual characteristics. For example, not all employees participate in equal measure to small-group problem solving activities and even in case of identical participation, positive or negative perception may depend upon specific characteristics shaping employee experience (e.g. goal difficulty, management support and team characteristics - Farris et al., 2009).

3.3.2. Employee Survey, Data Collection and Sample

Based on lean - employee well-being scientific literature and the JDRM, I developed a survey instrument containing the most relevant soft lean practices, lean-related job demands and employee well-being measures. The validation of selected constructs and questions was performed with the company managers, to verify the inclusion of all relevant practices and removal of non-relevant constructs.

All utilised scales were adapted from previously published studies with the aim to measure, at individual level, the underlying constructs. A first English version of the questionnaire was created and then translated into Italian. A back-translation technique (Italian into English again) was then used to check accuracy in translation. Questions were shuffled to prevent scales recognition during the completion. In agreement with Forza's recommendation (2016), I conducted a pilot study with a small group of workers, randomly selected, in order to pre-test the questionnaire tool, and anticipate potential problems (with the researcher observing how respondents filled in the survey and collecting their feedback). Unclear or misleading survey aspects were adjusted.

Then, the survey was administrated to 147 employees that filled in a paper-based version of the survey during their work shift. The survey return was anonymous with a dedicated survey box. During the analysis the database was cleaned, and 9 surveys were removed since they were not correctly filled-in (i.e. conflicting responses, too many missing answers that suggest negligence or lack of attention during fill-in procedure). The final sample size is of 138 valid surveys, that corresponds to the 26% of all production workers. The sample size is comparable with other previous studies (Cullinane et al., 2014) and sample characteristics are reported in Table 9.

Sample - Total 138					
Age (years)		**Organizational tenure (years)**		**Job Experience (years)**	
20-29	1 (1%)	<10	0 (0%)	<3	17 (12%)
30-39	33 (24%)	10-14	7 (5%)	3-5	22 (16%)
40-49	72 (52%)	15-20	78 (57%)	6-8	14 (10%)
50-59	31 (22%)	>20	52 (38%)	9-11	30 (22%)
>59	1 (1%)	Missing Values	1 (1%)	>12	55 (40%)
Missing Values	0 (0%)			Missing Values	0 (0%)
Sex		**Shift**		**Work Unit**	
F	55 (40%)	Yes	13 (9%)	Assembly	96 (70%)
M	82 (59%)	No	125 (91%)	Technology	42 (30%)
Missing Values	1 (1%)	Missing Values	0 (0%)	Missing Values	0 (0%)

Table 9 Sample characteristics

3.3.3. Measures

Table 10 shows utilized first-order constructs with their definitions.

CONSTRUCTS		DEFINITION
Work engagement (ENG)		The extent to which the worker perceives a positive, fulfilling work-related state of mind
Exhaustion (EXH)		The extent to which the worker perceives an intensive physical, affective and cognitive strain, as a long-term consequence of prolonged exposure to work stressors
SLP*	Small group problem Solving (GPS)	How much effective problem-solving teams are perceived, based on workers' individual experience
	Employee suggestions (ESUGG)	How much the worker thinks that employees' suggestions are encouraged and implemented in the plant, based on his/her individual experience
	Shop-floor contact (SFC)	The extent to which the worker thinks that managers are in the shop-floor and interact with employees, based on his/her individual experience
	Top management leadership for lean (TML)	The extent to which the worker perceives a high top managers' support for lean
	Coaching (COA)	The extent to which the worker perceives coaching as a form of facilitating learning to encourage growth and development
JIT-related job demands (JIT-JD)*	Work pace (PAC)	The extent to which the worker perceives an intensive work pace
	Interdependence (INT)	The degree to which the worker perceives that his/her own job depends on others' jobs and others' jobs depend on his/her individual job to be completed
Problem-solving job demands (PS-JD)		The degree to which the worker perceives that his/her job requires unique ideas or solutions

Table 10 Included constructs
**constructs measured as second-order factors*

3.3.3.1. Dependent variables

The dependent variables are here considered to be work engagement and exhaustion. Both variables were measured using OLBI scale (Demerouti et al., 2003, 2010; Halbesleben and Demerouti, 2005), in agreement with previous studies adopting the job demands-resources model (e.g., Demerouti et al., 2001) and the two mechanisms hypothesized by the model.

According to Halbesleben and Demerouti (2005), OLBI offers good and expanded alternative measures of exhaustion component of burnout and the opposite phenomenon of engagement. This perspective is reinforced by Demerouti et al.'s (2010) scale comparison study where OLBI was tested with more conventional UWES and MBI scales, for work engagement and exhaustion respectively. They provided further evidence of OLBI psychometric validity, showing that OLBI engagement/disengagement dimension is aligned with UWES work engagement dedication dimension and that OLBI exhaustion dimension is coherent with MBI exhaustion factor. However, as mentioned in the previous chapter, it must be borne in mind that both engagement and burnout are generally operationalized as multidimensional constructs: work engagement is generally defined as the combination of high levels of vigour, dedication and absorption at work (Bakker et al., 2008); whist burnout, according to Maslach et al. (1996), is characterized by high scores on exhaustion and cynicism, and low scores on professional efficacy. Previous studies adopting the job demands-resources model have barely included all engagement and burnout dimensions. (e.g., Cullinane et al., 2014; Demerouti et al., 2010; Salanova and Schaufeli, 2008). Most of the studies include exhaustion as the single dependent variable of the energy depletion mechanism and a combination of vigor and dedication dimensions as the outcome of the motivation process.

In literature, some concern exists regarding the discrimination of UWES vigor and MBI exhaustion, since they are, at best, strongly connected and represent similar aspects of the phenomenon (Demerouti et al., 2010). In this sense, OLBI, using both positively and negatively phrased items that represent the exhaustion and dedication dimensions of burnout and work engagement respectively, offers a solid and parsimonious two-factor structure that fits with the two mechanisms hypothesized by the job demands-resources model and with the scope of this study.

3.3.3.2. Independent variables

SLP were measured as a second order construct that included five specific first-order constructs: small group problem solving, employee suggestions, shop floor contact, top management leadership for lean and coaching.

Small group problem solving and employee suggestions were measured with a 5-item scale each, both adapted from Bortolotti, Danese et al. (2015). Shop floor contact was measured through 5 items adapted from Anh and Matsui (2011). Top management leadership for lean was measured through 5 items adapted from previous studies (Flynn et al., 1994; Ugboro and Obeng, 2000).

Coaching was captured using an 8-item scale developed and tested by Ellinger et al. (2003, 2005) in line with implemented coaching practices.

Jit-related job demands were measured using a second-order construct including work pace adapted from Pejtersen et al. (2010) and task interdependence from Morgeson and Humphrey (2006). In this case, I combined measures of initiated and received task interdependence in a single interdependence scale since in repetitive production contexts adopting assembly line and job shops, the two aspects are strongly interconnected and there are no interesting theoretical reasons to treat them independently[1]. Problem-solving job demands were measured using a 4-item scale from Morgeson and Humphrey (2006).

For each item, respondents indicated their level of agreement on a seven-point Likert scale, from 1 (strongly disagree) to 7 (strongly agree). Items and correlation matrix are reported in Appendix B and D.

3.3.3.3. Control variables

As earlier individual-level researches on the topic have done, several control variables in the hierarchical regression analysis were included: sex, age, work unit, day job vs. shift job (with nights), organizational tenure and job experience (Cullinane et al., 2014; Demerouti et al., 2001; Jun et al., 2006; Parker, 2003; Rungtusanatham, 2001).

3.3.4. Measurement Models

Before proceeding with hypothesis tests, normality for all included items checking kurtosis and skewness was verified. According to Blome et al. (2013), maximum absolute values for univariate kurtosis and skewness must be below the suggested thresholds of 7 and 2, respectively (Curran et al.,

[1] This is even confirmed by the lack of discriminant validity between the two constructs in the considered sample using Bagozzi et al.'s method (1991)

1996). These threshold values are confirmed by other scholars (Byrne, 2016; Kline, 2015). All the items are below these thresholds but one (measuring exhaustion), that was removed for disproportionate skewness. Moreover, in agreement with several previous studies (Bou-Llusar et al., 2009; van den Broeck et al., 2008; Kurtmollaiev et al., 2018; Wu et al., 2015), to additionally consider possible deviations from normality in structural equation analyses (given that Likert scale is, by definition, discrete and therefore non-normal), Satorra and Bentler (1994) scaled goodness-of-fit test statistics were adopted. This approach, under conditions of non-normality, generally outperform their uncorrected versions (Byrne, 2016; Curran et al., 1996; Nevitt and Hancock, 2000).

As concerns common method bias, it was controlled prior data collection through items shuffling, and *ex-post* data collection through statistical tests. A confirmatory factor analysis (CFA) based on a single factor accounting for all data variance was performed revealing an inadequate fit ($\chi 2$=1327; $\chi 2/df$= 1,99; CFI=0.65; RMSEA=0.0963; SRMR=0.096). This was further supported by exploratory factor analysis including all interested items that revealed multifactor structure, characterized by 13 factors with eigenvalues > 1, accounting for the 70% of the common variance, and the first factor accounting for 19% of the common variance.

3.3.4.1. Convergent validity

In order to validate the measures, I performed confirmatory factor analysis (CFA) using maximum likelihood estimation in R package lavaan. Single-factor models were run for every first-order construct in agreement with previous authors (Bortolotti, Danese, et al., 2015; Jöreskog and Sörbom, 1989; Li et al., 2005). Model-fit statistics and factor loadings were verified to satisfy adequate fit ($\chi 2/df<3.0$, CFI >0.90, RMSEA<0.08, SRMR<0.08)[1] and convergent validity (factor loadings significant and > 0.50). Items strongly below 0.50 factor loading level or reducing fit were removed

[1] According to Kline, the minimum set of fit statistics that should be reported includes model chi-square with degrees of freedom and p-value, CFI, RMSEA and SRMR (Kline, 2015, p. 269)

following an iterative procedure, simultaneously preserving content validity of the constructs for the remaining items. Constructs with 3 items or less were tested with a second construct as a reference basis, in order to have enough information (degrees of freedom) to calculate the model. All specified item loadings were significant ($p<0.001$) and exceeded 0.5 value. Only one item belonging to the interdependence construct showed a loading a lower loading (0.45) but wasn't discharged to preserve content validity. This choice is in line with previous literature guidelines that identify 0.30 as loading critical limit (Hair et al., 2014; O'Leary-Kelly and Vokurka, 1998). Factor loadings are reported in Appendix B.

3.3.4.2. Second-order construct validation

In order to validate the second-order constructs, I followed the procedure proposed by Koufteros et al. (2009), to check whether the two second-order constructs (SLP and JIT-related job demands) better fit the data than their corresponding first-level constructs. This approach is needed to prove, besides theoretical pieces of evidence, the empirical soundness of second-order constructs postulation. Second-order SLP and JIT-related job demands constructs were tested together in 4 sequential models since JIT-related job demands construct is composed by only two first-order factors and a further construct beside that is needed to get an identified model[1] (Rindskopf and Rose, 1988). The first model included all items related to SLP, loading on a single SLP factor, and, all items belonging to work pace and interdependence, loading on a single JIT-related job demands factor. The second model included all first-order factors imposing no correlation among each other. The third model was similar to the second one, apart from letting all correlations among constructs as free. The fourth model included second-order constructs for SLP, and JIT-related job demands with their respective first-order constructs. Model 4 showed a better fit than model 1 and model 2 and

[1] In accordance with Rindskopf and Rose (1988), it is recommended to have at least four first-order factors if there is only one second-order factor. In case of less than four first-order factors for a second-order factor, in order to get a testable model, a further second-order factor is needed for the model to be identified (p. 54).

comparable fit with model 3[1]. Empirical data supported a second-order structure for SLP and JIT-related job demands (Table 11).

Goodness of fit indices for alternative models of factor structure	**Measurement Model**			
	Model 1 One first-order factor for SLP and One first-order factor for JIT related job demands	**Model 2** Seven first-order factors uncorrelated (equivalent to correlations = 0)	**Model 3** Seven first-order factors correlated (correlations let free)	**Model 4** One second order factor for soft lean practices (including five first-order factors) and one second order-factor for JIT-related job demands (including two second-order factors)
Chi-square (df)	468.18 (298)	715.731 (299)	347.539 (278)	358.551 (292)
Chi-square/df	1.57	2.39	1.25	1.23
CFI	0.869	0.676	0.948	0.950
RMSEA	0.064	0.119	0.050	0.047
SRMR	0.079	0.317	0.055	0.067

Table 11 Comparison among the different models tested

Model 4, testing the two constructs together, showed good fit to the data ($\chi^2(292) = 358.6$; $\chi^2/df = 1.228$; CFI=0.950; RMSEA=0.047; SRMR=0.067) and first-order constructs loading (on the respective second-order latent factor) are acceptable in terms of significance (p-val<0.001) and magnitude (> 0.50 - see Appendix C).

MacCallum et al.'s (1996) procedure was utilised to check that sample size was adequate in terms of statistical power. The sample size exceeded the minimum required to obtain a statistical power of 0.8 with 292 degrees of freedom at alpha of 0.05 under close fit hypothesis.

After validation, first-order constructs belonging to second-order constructs were parcelled, redefining them as single indicators obtained through respective items' means (Bortolotti, Danese, et al., 2015; Sila, 2007). Considering that previous structural analyses offered strong evidence as concerns the first-order constructs unidimensionality, parcelling might have a minor impact on estimated parameters (Nasser-Abu Alhija and Wisenbaker, 2006), but allows to obtain a testable model not overly specified (Little et al., 2002).

[1] It is worth noticing that, according to the literature, model 4, that included the second-order constructs, cannot have a better fit than model 3 that specifies only first-order constructs (Koufteros et al., 2009). In this case, the fit is comparable and even better due to the utilization of Satorra-Bentler robust indices.

3.3.4.3. First-order construct simplified model

A model containing all interested constructs (SLP, JIT-related job demands, problem-solving job demands, work engagement and exhaustion) was finally tested. CFA analysis showed an acceptable fit ($\chi^2(143) = 213{,}8$; $\chi^2/df = 1.495$; CFI=0.932; RMSEA=0.066; SRMR=0.066). The model confirms previous analysis and provides further evidence of convergent validity (all loadings>0. 50 and significant for p-val<0.001). The sample size of 138 was higher than the minimum sample size (104) required for 0.80 statistical power with 143 degrees of freedom at alpha of 0.05 under close fit hypothesis (MacCallum et al., 1996).

3.3.4.4. Discriminant validity

Discriminant validity analysis was performed through Bagozzi and Phillips's approach (1991). This method is based on Chi-square difference test among two nested models for each pair of interested factors, adjusted here for Satorra and Bentler's Chi-squares (Satorra, 2000). The first model included the two interested factors, not fixing the correlation among them. In the second model, based on the first one, the correlation is set to the unit (1). Two constructs are considered as distinct and discriminated if there is a significant difference between the two models based on Satorra's Chi-square difference test (2000). The analyses showed that all first-order constructs are discriminated from each other with a maximum p-value lower than 0.01. The same procedure was applied for second-order constructs and supported their discriminant validity with a corresponding p-value lower than 0.001. As a complementary assessment of discriminant validity, all correlation confidence intervals were calculated and it was verified that none of them included the value of 1 (Anderson and Gerbing, 1988).

3.3.4.5. Reliability

Composite reliabilities (CR) were calculated for all the constructs. All CR values exceed the threshold of 0.60 reported by Bagozzi and Yi (1988) (see Appendix B and C).

3.4. Results

3.4.1. Hierarchical Regression Results

Multiple hierarchical regression (HR) with control variables was run in SPSS 24 to test the hypotheses. As suggested by Cohen et al. (2003), normality of residuals and homoscedasticity were verified through graphical check of P-P plot linearity and random distribution of predicted values against residuals. Both were satisfactory. Multicollinearity was managed through mean-centring of all interaction variables (Jaccard et al., 1990) and variance inflation factors check. The highest variance inflation rate was 1.63, well below the limit of 5.

HR results are depicted in Table 12. Models 1 to 4 report the results for work engagement, whereas models 5 to 8 refer to exhaustion as the dependent variable. In Models 1 and 5 only the control variables are included. In Models 2 and 6 the main effects of SLP, problem-solving job demands, and JIT-related job demands are incorporated. In Models 3 and 7, the interaction term between SLP and JIT-related job demands is added, whereas model 4 and 8 incorporate the interaction between SLP and problem-solving job demands.

Predictors	Dependent variable Y: Work Engagement M1	M2	M3	M4	Dependent variable Y: Exhaustion M5	M6	M7	M8
Constant	5.489***	4.612***	4.772***	4.973***	3.266***	3.861***	3.672***	3.786***
Age	0.037	0.178	0.173	0.139	0.172	0.063	0.069	0.071
Employment period at the current company	0.074	-0.132	-0.112	-0.129	-0.055	0.095	0.071	0.094
Experience with current type of job	-0.137	-0.075	-0.091	-0.104*	-0.032	-0.069	-0.050	-0.063
Sex	0.227	0.196	0.274	0.241	-0.150	-0.108	-0.199	-0.117
Shift	0.069	0.178	-0.057	0.188	-0.296	-0.483	-0.204	-0.485
Work Unit	-1.216***	-0.221	-0.221	-0.289	0.912***	0.364	0.364	0.378
Soft Lean Practices (SLP)		0.854***	0.898***	0.809***		-0.579***	-0.631***	-0.569***
JIT-related job demands (JIT-JD)		-0.237**	-0.179*	-0.224**		0.243*	0.173ⁱ	0.240*
Problem-solving- job demands (PS-JD)		0.239***	0.212***	0.237***		-0.071	-0.038	-0.070
SLP*JIT-JD			0.254**				-0.301**	
SLP*PS-JD				-0.169*				0.035
R^2	0.249	0.655	0.681	0.669	0.146	0.331	0.374	0.332
R^2 adjusted	0.215	0.631	0.656	0.643	0.107	0.284	0.325	0.279
ΔR^2		0.406	0.026	0.014		0.185	0.043	0.001
F- value change	7.244***	50.207***	10.345**	5.457*	3.734***	11.813***	8.674**	0.138

Table 12 Hierarchical regression analysis. ł p-value < 0.10; p-value < 0.05; ** p-value < 0.01; *** p-value < 0.001. Unstandardized coefficients are reported*

Hypothesis H1 and H2 are supported by Models 2 and 6, with SLP linked negatively to exhaustion and positively to engagement. In addition, JIT-related job demands positively affect exhaustion and negatively affect work engagement, supporting H3 and H4 and their role as hindrance demands. Considering problem-solving job demands, their positive impact on work engagement (H6) is supported, but not the connection with exhaustion (H5 not supported). Models 3 and 7 confirm the theoretical expectations regarding the interaction among SLP and JIT-related job demands (H7a and H8a). Particularly, model 3 corroborates the idea that SLP might be more effective under more JIT-related demanding conditions and model 7 provides empirical foundation that JIT-related characteristics are perceived as less exhausting for those workers that experience higher SLP.

It is interesting to highlight that the analysis does not provide support to the assumption that problem-solving is an exhausting aspect of work (H5 not supported) nor that SLP can modify and reduce the negative effect of problem-solving on exhaustion (H7b not supported). Moreover, the interaction between SLP and problem-solving job demands on engagement is significant but negative (model 4), in contrast with H8b.

Finally, Cohen's procedure (1988) was utilised to verify statistical power thorough post hoc statistical power analysis with R-package *pwr*. Analysis suggested that power is beyond.99 for models 2, 3, 4, 6, 7, 8.

3.4.2. Structural Equation Modelling Results

To reinforce previous findings, hypotheses were tested even with moderated structural equation modelling (MSEM) using R package *lavaan*.

Ping's (1995) method based on two stages, was adopted to properly calculate interaction terms for H7a, H7b, H8a and H8b test. Firstly, the main effect model including SLP, problem-solving job demands, JIT-related job demands, work engagement and exhaustion was run. Then, previously estimated parameters were utilised as input values in the second stage, in which the interaction terms (both composed by a single item) were included in the structural model. The first interaction item was computed multiplying the sum of the items of SLP with the sum of JIT-related job demands items, and the second interaction item was computed by multiplying the sum of the items of SLP with the sum of the items of problem-solving job demands. For parsimonious reasons, controls were not included in SEM analysis[1], considering even the fact that previous HR analysis suggested that none of the control variables is consistently associated with the outcomes across the various models.

Figure 11 depicts the results for the second-step model. The indices indicated a satisfactory fit of the model to the data ($\chi^2(172) = 243{,}94$; $\chi^2/\text{df} = 1.418$; CFI=0.934; RMSEA=0.060; SRMR=0.0621).

It is worth noting that SEM results support all HR findings, except for one. Indeed, the prior surprising negative effect on engagement of the interaction between SLP and problem-solving job demands is non-significant in the structural model. A note of caution is due here because of these ambiguous and contradictory findings with H8b that is not supported.

[1] In previous HR analysis only work unit and experience with the current job were significantly related to engagement or exhaustion. However, even for these controls the effect is not consistently significant from the control models, through the main models, to the interaction models

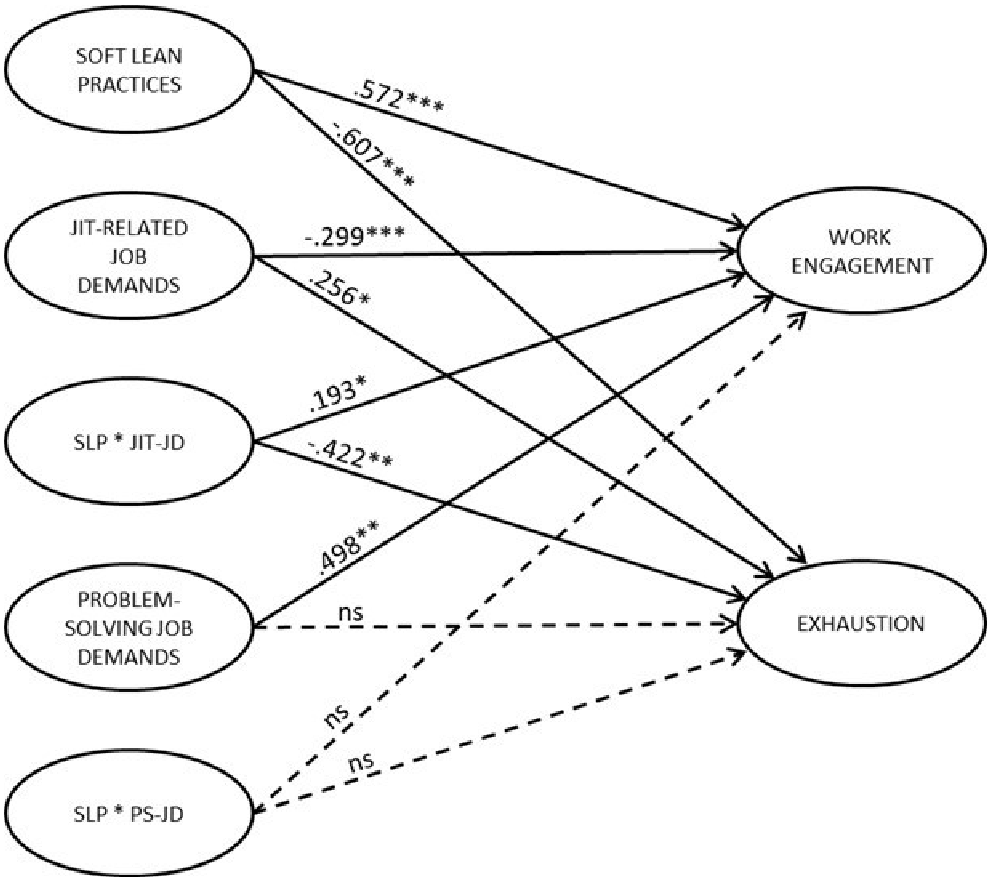

Figure 11 MSEM results. Standardized regression weights are reported.
** p-value < 0.05 level; ** p-value < 0.01 level; *** p-value < 0.001*

3.4.3. Interaction Plots

To gain further understanding of how SLP and JIT-related job demands interact according to the job demands-resources model, significant interactions found in HR and SEM are here further investigated and represented. SLP impact on work engagement at different degrees of JIT-related job demands and JIT-related job demands impact on exhaustion at different degrees of SLP (Cohen et al., 1983) are analysed in this section. Figure 12 shows the corresponding regression lines of SLP effect on work engagement for low, medium and high levels of JIT-related job demands, defined respectively as one standard deviation below the mean, equal to the mean and one standard deviation above the mean. Moreover, the values of the slopes and significance levels (Aiken and West, 1991) are included in the picture.

The picture confirms the hypotheses that the effect of SLP on work engagement increases with the rise of the degree of JIT-related job demands (as supported by H8a).

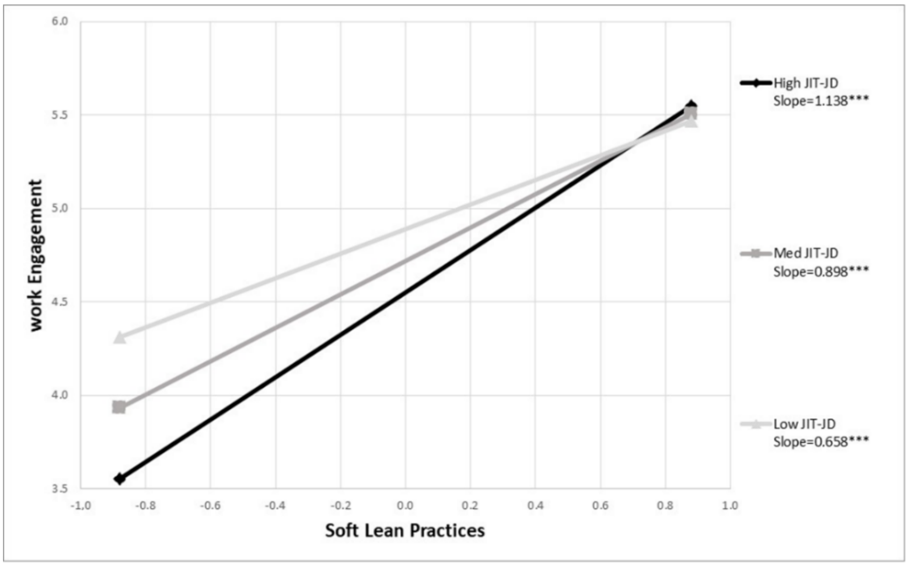

*Figure 12 Interaction plot showing the effect of soft lean practices on work engagement at different levels of JIT-related job demands. Significance calculated through simple slope test. *** p-value < 0.001. Note: Soft lean practices variable has been mean-centered.*

In Figure 13 the effect of JIT-related job demands on exhaustion at different levels of perceived SLP is depicted.

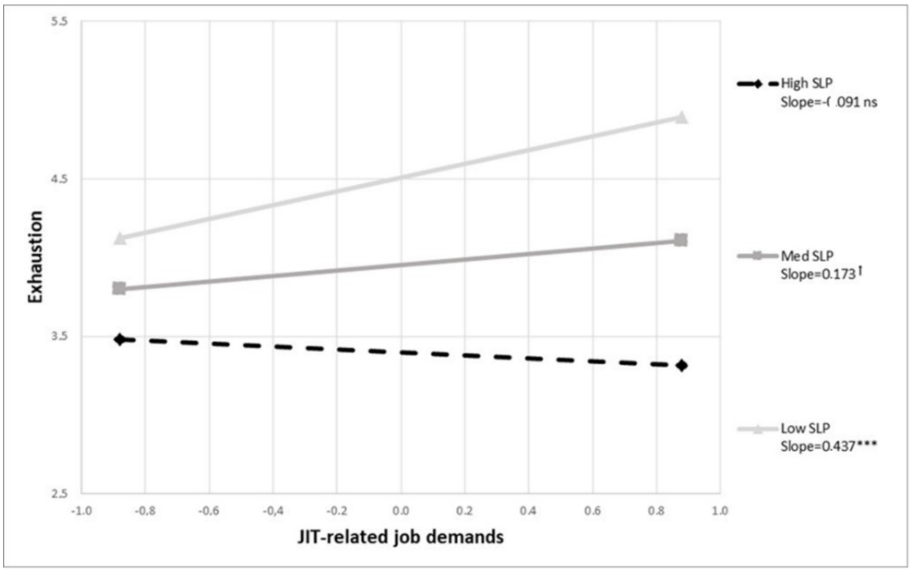

*Figure 13 Interaction plot showing the effect of JIT-related job demands on exhaustion at different levels of soft lean practices. Significance calculated through simple slope test. ƚ p-value < 0.10; *** p-value < 0.001. Note: JIT-related job demands variable has been mean-centered.*

In agreement with the JDRM and H7a, the effect of JIT-related job demands on exhaustion diminishes as perceived SLP rise. Moreover, slopes significance level decreases as SLP increase, turning to be severely non-significant when SLP are perceived as high (for one standard deviation above the mean the p-value is above 0.10).

Additional insights regarding these interaction effects can be provided by marginal effects plots developed using R-package *margins* (Figure 14).

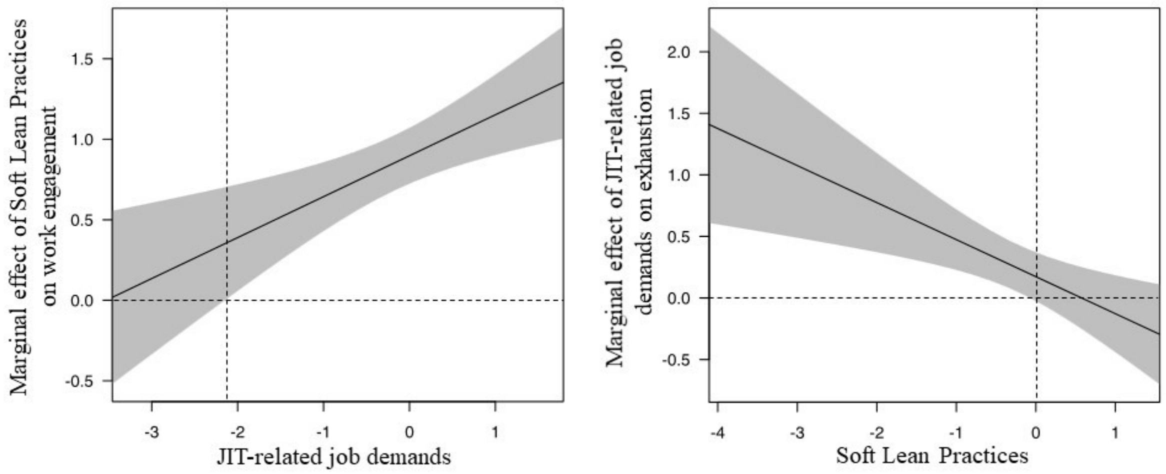

Figure 14 Marginal effects plots for the relationship between soft lean practices and work engagement at different degrees of JIT-related job demands (left) and for the relationship between JIT-related job demands and exhaustion at different degrees of soft lean practices (right). Note: In grey it is depicted the 95% confidence interval area for the marginal effect.

In the right-side picture in Figure 14, for each given value of JIT-related job demands on the x-axis, the straight line shows the predicted slope for SLP-work engagement relationship on the y-axis. The grey area represents the 95% confidence interval. The marginal effect graph shows that the estimated slope is increasingly positive and significant when the degree of JIT-related job demands moves beyond -2.15 (in the graph mean-centered values are displayed) within a 95% confidence interval. This is even more interesting considering that more than the 97% of the observations fall beyond the JIT-related job demands threshold of -2.15, where the moderation effect is significantly different from 0. In the left-side picture, the same representation is proposed for the marginal effect of JIT-related job demands on exhaustion at different degrees of SLP. Here, the analysis confirms that investigated job demands are perceived as more exhausting for lower levels of SLP. Specifically, below the SLP threshold of -0.07 (38% of the workforce), JIT-related job demands become significant for p-value<0.05, and positively related to exhaustion. This supports that workers experiencing low involvement in soft practices may be harmed by JIT conditions.

4. Discussion and Conclusions

4.1. Overview of the Chapter

This chapter deeply discusses the most important results as regards the empirical research previously presented. In the next section contributions to theory on lean and well-being are reported with a focus on novel findings and discussion of unexpected results. In the third section most relevant research implications for practitioners are presented, in order to guide managers to a lean implementation that is positive for both performance and employees. In the last section the most important limitations of the current study are reported, along with potential future lines of research on the topic.

4.2. Theoretical Contribution

The reported findings provide important contributions as regards the theoretical understanding of the impact of lean on well-being.

Firstly, the current research contributes to lean-employee well-being literature, and particularly to that stream of research composed by just few papers in the HRM field, that adopted the job demands-resources model to investigate the impact of lean manufacturing on production workers (Cullinane et al., 2014; Huo and Boxall, 2018). The positive impact of perceived soft lean practices on employee well-being has been confirmed by the presented results, given that soft lean practices are negatively linked to exhaustion and positively linked to engagement. These findings are in line with previous researches supporting a positive relationship between soft lean practices and employees psychophysical conditions (Conti et al., 2006; Cullinane et al., 2014; Huo and Boxall, 2018; Longoni et al., 2013; Mullarkey et al., 1995; Saurin and Ferreira, 2009). In addition, the negative effect of JIT-related job demands is confirmed, being negatively related to exhaustion and positively related to engagement. This represents a distinctive contribution in comparison to previous studies. To a certain degree, this finding sheds doubts on the view of some lean theorists supporting that aspects such as buffer reduction and work pace increase may stimulate engagement of employees (de Treville and Antonakis, 2006). Moreover, the research confirms, as depicted by Figure 12, that soft lean practices have a higher salience on engagement for those employees that are exposed to more demanding conditions in terms of JIT-related work characteristics. Indeed, workers experiencing less work pace and interdependence are also less susceptible to soft lean practices impact on work engagement, as shown in the figure. That fits perfectly the job demands-resources model, supporting that those workers exposed to inferior demands, do not need as many resources as those experiencing more stressing and wearing working conditions, since they cannot take as much benefits from these extra positive work characteristics (soft lean practices) as their colleagues experiencing higher demands (JIT-related job demands). Moreover, comparing high soft lean practices-high JIT-related job demands employees with high soft lean practices-low JIT-related job demands employees, it is interesting to notice that the first group reports a slightly higher engagement when compared to the second group (see Figure 12). Despite minimal, this finding further clarifies the crucial role of soft lean practices for employee well-being, since, thanks to them, employees perceiving higher work pace and interdependence can experience comparable or higher work engagement of those employees in less severe conditions.

As regards SLP moderation on the exhaustive effect of JIT-related job demands, to the best of my knowledge, this is the first contribution able to provide quantitative evidence supporting that soft lean practices can alleviate the impact on exhaustion of JIT-related demands. A previous study performed by Cullinane et al.'s (2014) tried to investigate a similar aspect but failed to report a significant buffering effect of lean resources on lean demands-exhaustion relationship. This significant result could be related to the acknowledgment of two distinct types of job demands (i.e., challenge and hindrance job demands). This finding further underpins the crucial role of the human-related lean pillar in line with previous theoretical and qualitative research on lean and employee well-being, suggesting that just-in-time tools without the soft side of lean, may have harm workers' well-being (Longoni et al., 2013; Parker et al., 1995; Stimec and Grima, 2018; de Treville and

Antonakis, 2006). Moreover, it is worth noting that in the investigated context, soft lean practices can even erase the negative effect of JIT-related demands on exhaustion, as shown by Figure 13, in which the significance level of job demands-exhaustion relationship decreases with the increment of soft lean practices, turning to be severely non-significant (with a p-value above 0.10) for those employees perceiving high soft lean levels. The finding is particularly important for lean theory, since it provides, at micro-individual level, empirical foundation that lean manufacturing can be implemented without harming employee well-being, even for employees performing simple repetitive tasks.

Overall, these findings extend previous job demands-resources model research on lean (Cullinane et al., 2014; Huo and Boxall, 2018), since a broad set of perceived soft lean practices (i.e., small group problem solving, employee suggestions, shop floor contact, top management leadership for lean and coaching) has been utilized. Additionally, they support that employees do not perceived soft lean practices as mere tools, but as real organizational resources that may help them deal with demands and improve their well-being. Furthermore, given the operationalization of soft lean, it is not just a matter of participation, but, more importantly, of how much employees perceive these soft lean practices as effective in in their job and work environment.

As concerns problem-solving job demands, this research has been unable to demonstrate that they act as challenge job demands. Although these findings support that problem-solving job demands are positively related to engagement, their effect on exhaustion is non-significant. Therefore, in the investigated context, it is more appropriate to consider problem-solving as a job resource rather than a job demand. Interestingly, these findings are in contrast with previous investigations that reported a negative impact of problem-solving on workers' well-being (Bouville and Alis, 2014; Jackson and Mullarkey, 2000), but are partially in line with those of Huo and Boxall (2018). They reported a significant effect of problem-solving on engagement and an effect on exhaustion that depends on lean job resources (that included some soft lean practices): positive when lean resources are low, and negative when lean resources are high. As concerns this research, a possible explanation for the lack of problem-solving exhaustive effect, could be that the investigated plant is an example of high level of lean implementation with detailed standard routines to cope with operative issues and an organizational culture oriented towards PDCA and experimentation with low or no risks of blame or "blame game" in case of failure. Indeed, when a problem arises during production, workers are aware that they can try to solve it by themselves or eventually call for line leader support. Workers and supervisor may decide to trigger a specific problem-solving operative procedure to cope with the issue and eventually activate formal problem-solving team. Overall, these aspects could have removed those negative and exhausting effects associated with problem-solving demands, since they limit unpredicted consequences of workers' failures in facing a problem. As concerns soft lean practices-problem-solving demands interaction, these results are in contrast with Huo and Boxall (2018), since the analysis does not support any significant interaction between the two constructs. This result, to a certain degree, is expected given that in the considered sample, problem-solving does not seem to act as a demand. This brings down the interaction hypotheses as postulated by the job demands-resources model.

Two other important contributions are given to debate concerning how to measure lean when its impact on well-being is investigated.

Firstly, this research strongly supports the importance of considering lean as a multidimensional construct and examining the impact of different lean facets on workers' well-being. These findings confirm Hasle et al.s' (2012) idea that the relationship between lean and the employee well-being is a complex one, confirming that distinct lean aspects can have opposite effects on well-being, and even interact each other. This sheds further light to those previous investigations reporting mainly negative effects of lean on employees. As stated by numerous other researches (Hasle et al., 2012; Longoni et al., 2013), previous negative findings may have considered sick applications, in which lean manufacturing was partly implemented with too much emphasis on slack and waste activities removal, not properly taking into consideration the central Toyota principle of respect for humanity and employee involvement. These findings provide a new lens on these studies extending the relevance of the soft side of lean, that not only directly affect employee well-being, but also buffer the negative effect of JIT. Given these double effect, soft lean practices disregard is a crucial point to critically interpret previous research that investigated plants implementing only hard-lean tools and concluded that lean is bad (see for instance section 2.3.2.5). For example, the recent work of Stewart et al. (2016) examining lean adoption in 4 automotive production facilities located in Europe and reporting major negative health effects on employees, concluded that “kaizen became a veil for the ratcheting-up of work intensity”. However, assessing carefully the four cases, in half of them, there was a failure to genuinely involve employees, reporting that they “did not involve any meaningful input into discussions by workers” with “a number of examples of management disdain for worker suggestions”. Just one of the remaining plants reported a satisfactory level of participation. In parallel with Stewart et al., many other studies that reported negative effects of lean manufacturing on workers, have considered contexts where soft lean practices were not adequately implemented (Bruno and Jordan, 2002; Lewchuk et al., 2001; Lewchuk and Robertson, 1997; Parker, 2003; Stewart et al., 2009; Yates et al., 2001).

Secondly, this study sheds serious doubts on researches that investigated lean at plant level interviewing few employees or just managers. Indeed, the research demonstrates that even considering a production facility with a high lean level and all workers trained in basic lean principles and tools, there is an important variability of employees’ perception of soft lean practices, demands, engagement and exhaustion. In agreement with other scholars (Longoni et al., 2013; Stimec and Grima, 2018), this research supports that future contributions must address the topic including individual-level perspectives of production workers

4.3. Managerial Contribution

Reported findings provide an important contribution to managerial practice as well, given the widespread of lean manufacturing as the dominant production paradigm in many countries.

Empirical evidence that soft lean practices can offset JIT negative effect is particularly relevant for managers, since it may give an indication on the correct formula for implementing lean without damaging employee well-being. In fact, looking at Figure 12 and Figure 13, it is worth noting that those employees perceiving a combination of low demands (JIT-related job demands level one standard deviation below the mean) and high resources (soft lean practices level one standard deviation above the mean) do not perceive lower exhaustion or higher engagement compared to workers exposed to high demands-high resources (+1SD above the mean) combination. This may shed doubts on the idea that the ideal lean implementation recipe is to maximize employee involvement while minimizing those negative lean elements of JIT. Even though JIT-demands effect on exhaustion is confirmed, findings support also that more demanding working conditions may improve the salience of soft practices on engagement and that soft lean practices can totally offset JIT impact on exhaustion. This can be further analysed through the lens of the job demand-control model (Karasek, 1979). Karasek hypothesized that, in contrast with those high strain jobs characterized by a high job demands-low job control combination, there are those "active-learning jobs", combining adequate autonomy with high demands. The basic assumption is that most engaging jobs are based on high demands but even provide workers with enough resources to successfully cope with their demands. Based on this model, demands minimization with concurrent resources maximization could bring to low satisfaction and passive working conditions. Management should pay attention to couple high demands with high level of soft lean practices, in order to ensure active working conditions combining productivity and efficiency requirements with workers' needs for engaging work conditions.

A second contribution is related to fact that the research considered lean as variable phenomenon even inside the same production facility. Measuring perceived soft lean practices at individual level, results clearly demonstrate that employees do not perceive lean in the same manner. An important recommendation to lean managers is to monitor individual level perception of soft lean practices since there may be a relevant variability, that in turn is a predictor of employee well-being. Therefore, it is important not to rely only on plant or area level metrics based on managerial opinion or quantitative indicators, but integrate some feedback from employees as regards small-group problem solving, lean leadership, coaching and so on, in order to avoid a fictitious adoption of soft lean.

4.4. Limitations and Future Research

The first limitation of this study regards the cross-sectional nature of the data utilized to test the hypotheses. Ideally, future researches should adopt a longitudinal design in order to test the causality relationship between perceived soft lean practices, job demands, engagement and exhaustion, considering even reverse causation. According to the job demands-resources theorists (Bakker and Demerouti, 2017), job resources influence motivation, but even motivated employees can influence their job resources adopting more proacting behaviours, activating a positive gain spiral . On the other hand, a similar reverse effect has been observed as regards the job impairment mechanism with job demands that increase exhaustion, but even employees who experience high job strain that tend to increase their job demands over time in a so-called negative loss spiral. Future studies can investigate if the presence or absence of soft lean practices may lead to these positive gain or negative loss cycles, further reinforcing the salience of these lean aspects for employee well-being.

Secondly, this study adopted a single level of analysis. Future studies can adopt a multi-level perspective onto the phenomenon of lean and employee well-being since some lean practices such as JIT tools, are applied at organizational or work unit level, but workers only perceive their effect in terms of job aspects and well-being. To further validate the negative impact of some specific lean practices, what is needed is a call for future research able to investigate different lean specific dimensions and their interactions through a multilevel perspective, collecting data from a large number of organisations and measuring lean implementation at organizational level through management interviews and at individual level through an adequate number of surveyed employees. Thanks to a relatively novel set of multilevel statistical techniques (Hox et al., 2010; Mathieu et al., 2012), it is possible investigate the impact of organizational-level lean practices on individual perception of specific lean practices, job aspects and well-being. Moreover, this may shed further light on plant-level and employee-level perceived implementations of specific soft practices, assessing if eventual gaps in perception may affect the employee well-being.

Third, the database includes employee data from a single Italian plant belonging to a multinational corporation producing home appliance goods. Whilst the plant adopted a rather standard lean-inspired production system and the single plant choice may have limited the number of other confounding variables not included in the research framework, it restricts the generalisability of the findings. Future studies should test investigated hypotheses across a variety of industries and nations, to further extend presented results. Future studies should even investigate the role of other specific contextual variables in affecting the relationships between soft lean practices, job demands and well-being. In agreement with Hasle et al. (2012), specific contextual factors such as lean maturity implementation, implementation strategy, previous union-management relationships and job complexity may modify soft lean practices, job demands and employee well-being relationships (Conti et al., 2006; Neirotti, 2018).

Fourth, this study includes some inconclusive results. In contrast with Huo and Boxall (2018), problem-solving does not interact significantly with soft lean practices. Together with the lack of an exhausting effect of problem-solving, the lack of soft lean practices-problem-solving interaction supports that, in the investigated context, problem-solving is perceived as a resource rather than a demand. Future research should clearly investigate the role and perception of problem-solving on employee well-being, considering its interactions with other lean related aspects that may trigger this problem-solving change from an exhaustive to an engaging job aspect.

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Appendix A– Table of papers included in the literature review

Article	Methodology	Sector	Unit of Analysis	Overall Effect of Lean
Adler et al., (1997)	Qualitative	Automotive	Organization/Plant	-
Anderson-Connolly et al., (2002)	Mixed - Qualitative + Quantitative	Other manufacturing	Individual	+/-
Angelis et al., (2011)	Mixed - Qualitative + Quantitative	Other manufacturing	Multiple level of analysis	+/-
Babson, (1993)	Quantitative	Automotive	Organization/Plant	-
Backstrom and Ingelsson, (2015)	Quantitative	Service	Individual	+
Bouville and Alis, (2014)	Quantitative	Other manufacturing	Individual	-
Brown and O'Rourke, (2007)	Qualitative	Other manufacturing	Organization/Plant	-
Bruno and Jordan, (2002)	Quantitative	Automotive	Organization/Plant	-
Carter et al., (2013)	Mixed - Qualitative + Quantitative	Service	Multiple level of analysis	-
Conti et al., (2006)	Mixed - Qualitative + Quantitative	Other manufacturing	Multiple level of analysis	+/-
Cullinane et al., (2014)	Quantitative	Other manufacturing	Individual	+/-
Cullinane et al., (2017)	Quantitative	Other manufacturing	Multiple level of analysis	+/-
de Haan et al., (2012)	Quantitative	Service	Individual	=
de Koeijer et al., (2014)	Theoretical		Multiple level of analysis (suggested)	
de Treville and Antonakis, (2006)	Theoretical		Multiple level of analysis (suggested)	
Dellve et al., (2015)	Mixed - Qualitative + Quantitative	Service	Organization/Plant	+
Dellve et al., (2018)	Mixed - Qualitative + Quantitative	Service	Organization/Plant	Unclear
Drotz and Poksinska, (2014)	Qualitative	Service	Organization/Plant	+/-
Fullemann et al., (2016)	Quantitative	Service	Multiple level of analysis	+/-
Groebner and Mike Merz, (1994)	Quantitative	Other manufacturing	Team/Group	=
Hakansson et al., (2017)	Mixed - Qualitative + Quantitative	Other manufacturing	Organization/Plant	+
Hakansson et al., (2017)	Mixed - Qualitative + Quantitative	Other manufacturing	Organization/Plant	+
Holden et al., (2015)	Mixed - Qualitative + Quantitative	Service	Organization/Plant	+
Huo and Boxall, (2017)	Mixed - Qualitative + Quantitative	Other manufacturing	Individual	+/-
Ingelsson and Backstrom, (2017)	Mixed - Qualitative + Quantitative	Service	Organization/Plant	Unclear
Jackson and Martin, (1996)	Quantitative	Other manufacturing	Team/Group	-
Jackson and Mullarkey, (2000)	Mixed - Qualitative + Quantitative	Other manufacturing	Team/Group	+/-
Klein, (1991)	Qualitative	Other manufacturing	Organization/Plant	Unclear
Lewchuk and Robertson, (1996)	Quantitative	Automotive	Organization/Plant	-
Lewchuk and Robertson, (1997)	Quantitative	Automotive	Organization/Plant	-
Lewchuk et al., (2001)	Quantitative	Automotive	Organization/Plant	-
Lindskog et al., (2016)	Quantitative	Service	Individual	+/-
Lipinska-Grobelny and Papieska, (2012)	Quantitative	Other manufacturing	Organization/Plant	+
Longoni et al., (2013)	Qualitative	Other manufacturing	Organization/Plant	+/-
Mehri, (2006)	Qualitative	Automotive	Organization/Plant	-

Mullarkey et al., (1995)	Quantitative	Other manufacturing	Organization/Plant	+
Nikolou-Walker and Lavery, (2009)	Action research	Other manufacturing	Organizational Unit/Process	+
Parker, (2003)	Quantitative	Automotive	Team/Group	-
Procter and Radnor, (2014)	Qualitative	Service	Organizational Unit/Process	+/-
Rodriguez et al., (2016)	Experimental	Other manufacturing	Team/Group	+
Saurin and Ferreira, (2009)	Mixed - Qualitative + Quantitative	Automotive	Multiple level of analysis	+
Schouteten and Benders, (2004)	Mixed - Qualitative + Quantitative	Other manufacturing	Individual	Unclear
Schultz et al., (1998)	Experimental	Service	Organizational Unit/Process	-
Seppala and Klemola, (2004)	Mixed - Qualitative + Quantitative	Other manufacturing	Multiple level of analysis	+/-
Simons et al., (2017)	Mixed - Qualitative + Quantitative	Service	Multiple level of analysis	+
Smith et al., (2012)	Qualitative	Service	Organization/Plant	+
Sprigg and Jackson, (2006)	Quantitative	Service	Individual	-
Stanton et al., (2014)	Qualitative	Service	Project	+
Sterling and Boxall, (2013)	Qualitative	Other manufacturing	Team/Group	+/-
Stewart et al., (2016)	Mixed - Qualitative + Quantitative	Automotive	Organization/Plant	-
Ulhassan et al., (2014)	Mixed - Qualitative + Quantitative	Service	Organizational Unit/Process	+
Vidal, (2007)	Qualitative	Other manufacturing	Multiple level of analysis	=
Womack et al., (2009)	Quantitative	Automotive	Production Jobs	+/-
Yates et al., (2001)	Quantitative	Automotive	Organization/Plant	-

Appendix B – Survey items, loadings, composite reliability and p-values

"Please, think about your work and your personal experience and indicates to what extent you agree with the following statements"

Items	Std loading	p-value
Work engagement (CR=0.86)		
I always find new and interesting aspects in my work	0.90	***
It happens more and more often that I talk about my work in a negative way (R)	-	-
Lately, I tend to think less at work and do my job almost mechanically (R)	0.65	***
I find my work to be a positive challenge	0.82	***
Over time, one can become disconnected from this type of work (R)	-	-
Sometimes I feel sickened by my work tasks (R)	-	-
This is the only type of work that I can imagine myself doing	0.59	***
I feel more and more engaged in my work	0.70	***
Exhaustion (CR=0.71)		
There are days when I feel tired before I arrive at work	0.55	***
After work, I tend to need more time than in the past in order to relax and feel better	-	-
I can tolerate the pressure of my work very well (R)	-	-
During my work, I often feel emotionally drained	0.63	***
After working, I have enough energy for my leisure activities (R)	0.74	***
After my work, I usually feel worn out and weary	0.55	***
Usually, I can manage the amount of my work well (R)	-	-
When I work, I usually feel energized (R)	-	-
Small group problem solving (CR=0.86)		
During problem solving sessions, there is an effort to get all team members' opinions and ideas before making a decision	0.73	***
Our plant forms teams to solve problems	-	-
In the past three years, many problems have been solved through small group sessions	0.85	***
Problem solving teams have helped improve manufacturing processes at this plant	0.80	***
Employee teams are encouraged to try to solve their own problems, as much as possible	0.74	***
It is not used problem solving teams much, in this plant	-	-
Employee suggestions (CR=0.83)		
Management takes all my product and process improvement suggestions seriously	0.84	***
I am encouraged to make suggestions for improving performance at this plant	0.84	***
Management tells me why my suggestions are implemented or not used	-	-
Many of my useful suggestions are implemented at this plant	0.65	***
My suggestions are never taken seriously around here (R)	0.58	***
Shop-floor contact (CR=0.77)		
Managers in this plant believe in using a lot of face-to-face contact with shop-floor employees.	0.86	***
Engineers are located near the shop-floor, to provide quick assistance if production stops.	-	-
Our plant manager is seen on the shop-floor almost every day.	-	-
Managers are readily available on the shop-floor when they are needed.	0.64	***
Manufacturing engineers are often on the shop-floor to assist with production problems.	0.67	***
Top management leadership for lean (CR=0.86)		
Top management has assumed the responsibility for initiating and maintaining lean goals and culture.	0.88	***
Top management's vision and commitment to lean are continually communicated to all employees.	-	-
Top management provides personal leadership for continuous improvement.	0.76	***
Our top management creates and communicates a vision focused on continuous improvement.	-	-
Our top management is personally involved in improvement projects.	0.79	***
Coaching (CR=0.90)		
My supervisor uses analogies, scenarios, and examples to help me learn	0.78	***
My supervisor encourages me to broaden my perspectives by helping me to see the big picture	0.85	***
My supervisor provides me with constructive feedback	0.76	***
My supervisor solicits feedback from me to ensure that his/her interactions are helpful to me	0.72	***
My supervisor provides me with resources so I can perform my job more effectively	-	-
To help me think through issues, my supervisor asks questions, rather than provide solutions	-	-
My supervisor sets expectations with me and communicates the importance of those expectations to the broader goals of the organization	-	-
To help me see different perspectives, my supervisor role-plays with me.	0.87	***

Work pace (CR=0.86)		
I have to work very fast	0.93	***
I work at a high pace throughout the day	0.85	***
It is necessary to keep working at a high pace	0.65	***
Interdependence (CR=0.66)		
The job requires me to accomplish my job before others complete their job.	0.57	***
Other jobs depend directly on my job	-	-
Unless my job gets done, other jobs cannot be completed	0.54	***
The job activities are greatly affected by the work of other people	-	-
The job depends on the work of many different people for its completion	0.45	***
My job cannot be done unless others do their work	0.72	***
Problem-solving demands (CR=0.66)		
The job involves solving problems that have no obvious correct answer	0.66	***
The job requires me to be creative	-	-
The job often involves dealing with problems that I have not met before	0.62	***
The job requires unique ideas or solutions to problems	0.59	***

Notes:
R: reverse-coded
In italics, the items that were dropped after CFA
*** Significant at a 0.001 level

Appendix C – Second-order construct loadings, composite reliability and p-values

Items	Std loading	p-value
Soft lean practices (CR=0.96)		
Small Group Problem Solving	0.95	***
Employee Suggestions	0.94	***
Shop Floor Contact	0.91	***
Top Management leadership for Lean	0.88	***
Coaching	0.89	***
Jit-related job demands (CR=0.69)		
Work pace	0.581	***
Interdependence	0.934	***

Notes:
*** Significant at a 0.001 level

Appendix D - Correlation matrix

The square root of AVE reported in the diagonal. Mean and Standard Deviation (between round brackets) are reported in the first column.
* p-value < 0.05; ** p-value < 0.01

Variables	Mean (SD)	1	2	3	4	5	6	7	8	9	10
1. ENG	4.74 (1.28)	**.740**	-.602**	.627**	.627**	.648**	.599**	.666**	-.150	.006	.582**
2. EXH	3.93 (1.18)		**.622**	-.399**	-.450**	-.485**	-.377**	-.463**	.193*	.002	-.331**
3. GPS	5.47 (0.93)			**.780**	.724**	.721**	.737**	.711**	.010	.152	.461**
4. SUG	5.44 (0.95)				**.739**	.693**	.725**	.725**	-.047	.178*	.407**
5. SFC	5.25 (1.07)					**.728**	.670**	.684**	.003	.171*	.404**
6. TML	5.81 (0.87)						**.813**	.633**	-.063	.131	.377**
7. COA	5.24 (1.21)							**.795**	-.038	.169*	.494**
8. PAC	5.28 (1.21)								**,819**	.409**	-.015
9. INT	5.14 (1.04)									**.578**	.236**
10. PRS-JD	4.37 (1.34)										**.625**

Variables: Engagement ENG, Exhaustion EXH, Small group problem-solving GPS, employee suggestion SUG, Shop floor contact SFC, Top management leadership for lean TML, Coaching COA, Work pace PAC, Interdependence INT, Problem-solving PRS-JD