Practical implications and future research agenda of lean manufacturing

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Practical Implications and Future Research Agenda of Lean Manufacturing: A Systematic Literature Review

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Abstract
Academic literature on Lean Manufacturing (LM) is widely available. However, due to its fragmentation, the contribution of LM from practical and academic perspectives is controversial. This paper establishes the practical implications of LM studies carried out worldwide and identifies novel research streams. A Systematic Literature Review (SLR) of peer-reviewed journal articles was conducted. A total of 401 articles published in 61 journals during 2010-2019 were collected from four major management science publishers. An “affinity diagram” was applied to organize the data into natural and logical themes. Conceptual frameworks with regard to LM practical implications and future research agenda were formulated. Meaningful themes of LM practical implications and future research suggestions were revealed and classified into two categories. In category one pertaining to the internal nature of LM, themes related to the pre-implementation, implementation and post-implementation phases of LM were identified. In category two pertaining to the external nature of LM, themes related to the country in which the companies operate, the diverse managerial systems available, and the methodological research approach were identified. The main themes supported in the literature by most references were determined. Finally, respective statements concerning the practical implications of LM and the future research agenda are analytically presented.

Key words – Lean manufacturing, Systematic literature review, Practical implications, Future research agenda.

1. Introduction
The current business environment is characterized by globalization, the opening up of new markets, fierce market competition and more demanding customers (Jasti and Kodali 2014a; Knol et al. 2018; Ghobadian et al. 2018). Under such circumstances, companies all over the world are facing many obstacles in their effort to survive and be competitive (Bevilacqua, Ciarapica, and Sanctis 2017b). To find solutions to the challenges that manufacturing companies are subjected to, they need to adapt their management style (Shamah 2013; Uhrin, Moyano-Fuentes, and Camara 2019) and look for new manufacturing strategies (Nawanir, Lim, and Othman 2016). Lean Manufacturing (LM) has been one of the most widely accepted manufacturing strategies and management styles deployed by organizations worldwide to enhance their business performance (Ghobadian et al. 2018) and boost their competitiveness (Abreu-Ledon et al. 2018; Galeazzo and Furlan 2018). For this reason, the application of LM has spread all over the globe (Bhamu and Sangwan 2014), from companies in developed economies, particularly the USA and Europe, to companies in developing economies, particularly in Asia and the Indian subcontinent (Bhamu and Sangwan 2014; Chaplin, Heap, and O’Rourke 2016; Negrao, Filho, and Marodin 2017; Henao, Sarache, and Gomez 2019). Since its emergence in the automotive industry and more specifically in the Toyota Motor Company (Bhamu and Sangwan 2014; Samuel, Found, and Williams 2015; Cocca et al. 2019), LM has been adapted for use in almost all manufacturing and service industries (Samuel, Found, and Williams 2015; Hopp 2018), both private and public (Samuel, Found, and Williams 2015), irrespective of size (Hu et al. 2015), as well as in many aspects of organizational operations (Abreu-Ledon et al. 2018; Zhu, Yuan, and Zhang 2018).
Following the widespread application of LM, its research and academic literature has increased (Pinho and Mendes 2017; Erthal and Marques 2018; Onofrei et al. 2019) especially from the beginning of the twenty-first century (Bhamu and Sangwan 2014; Samuel, Found, and Williams 2015). Accordingly, the current literature provides numerous commendable examples of the theory and practices of Lean, especially in discrete manufacturing (Marodin and Saurin 2013; Camuffo, Stefano, and Paolino 2017; Panwar et al. 2015). The plethora of the LM studies carried out worldwide (Samuel, Found, and Williams 2015; Pinho and Mendes 2017; Tortorella and Fettermann 2018b), constitute the basis on which the present study is able to give insights into LM from a practical and research perspective.

Due to the various meanings, and their evolvement, in the literature around Lean philosophies, principles, and measurement, LM has not been clearly and consistently defined (Stone 2012; Tortorella and Fettermann 2018b; Ciano et al. 2019). According to Pettersen (2009), authors seem to have different opinions on which characteristics should be associated with the LM concept. Ghobadian et al. (2018) also point out that there is no broad consensus as to what constitutes LM. Stone (2012) notes that confusion surrounding exactly what LM means has resulted in numerous implementation approaches often starting and ending with misguided efforts. For instance, Narayanamurthy and Gurumurthy (2016a) support the view that the diverse leanness assessment methodologies available in the literature have created complexities and confusion among both academicians and practitioners when they have to choose a suitable assessment method. Therefore, the confusion on a theoretical level is also problematic on a practical level when organizations aim to implement the Lean concept (Pettersen 2009; Narayanamurthy and Gurumurthy 2016a). There are also considerable differences between LM as practiced in reality compared to many descriptions in the literature (Langstrand and Drotz 2016). According to Stone (2012), the term Lean, and its association with “Japanese management” techniques, has caused confusion and difficulty when addressing LM outside the manufacturing context. In the same line, Bevilacqua, Ciarapica, and Sanctis (2017b) highlight the fact that a lot of scepticism still remains regarding attainable results and the possibility of applying the Lean approach outside high-volume manufacturing and stable contexts. Langstrand and Drotz (2016) state that the ambition of predicting the output results based on a general concept such as Lean is unreasonable, given that what is done under the LM banner differs from case to case. Lean takes many different forms (i.e. context, implementation and practice) which will have different effects on employees’ working environments, health and well-being. In this way, the relationship between LM and the working environment is not a simple one (Hasle et al. 2012).

From the aforementioned discussion, it is apparent that the existing body of knowledge on LM is disperse and diverse in nature making it difficult for researchers and practitioners to gain a real grasp of this topic (Yadav et al. 2017). So, LM is still a controversial concept in both academic and business environments (Hasle et al. 2012; Samuel, Found, and Williams 2015). To support the evolution of Lean theory and methods, research scholars should not only address the research opportunities but also understand more completely and communicate more clearly the essence and applications of Lean (Hopp 2018). Langstrand and Drotz (2016) suggest research on the implementation of LM go beyond the ‘label’ and consider the operationalised practices associated with the general concept. In light of these suggestions and the importance of LM for the business and academic worlds (Jasti and Kodali 2015; Abreu-Ledon et al. 2018), this study deals with LM practical implications already provided by researchers to practitioners and identifies the need for future research studies. The results of this study could therefore enrich the LM practical and theoretical
implications. In so doing, the foundations are being set for clarifying the above mentioned
controversies.

Although some LM literature review studies have already been published (Negrao,
Filho, and Marodin 2017), Uriarte, Ng, and Moris (2020) point out that there is still a lack of
reviews in this area. This results in a limited understanding of LM across industries at a
conceptual and technical level which is also supported by Abolhassani, Layfield, and
manufacturing, and Filho, Ganga, and Gunasekaran (2016) focusing on Brazilian small and
medium-sized enterprises (SMEs). Hence, LM practitioners are still experimenting through
"learning by doing" to see what works and what does not, as practical implementation guide-
lines have not been laid down yet (Tyagi et al. 2015). Providing insights into the practical
implications of LM as well as the future research agenda will fill the above mentioned
literature gap and, moreover, make the understanding of LM across industries clearer, thus
reducing the "learning by doing" phenomenon.

According to Tranfield, Denyer, and Smart (2003), undertaking a review of the
literature to provide the best evidence for forming policy and practice in any discipline is a
key research objective for the academic and practitioner communities. As far as Lean is
concerned, Uriarte, Ng, and Moris (2020) suggest further literature review studies, while,
more specifically, Psomas and Antony (2019) and Pearce and Pons (2019) propose
Systematic Literature Review (SLR) studies. In the same line, Negrao, Filho, and Marodin
(2017) note that the set of the available information on Lean should be enlarged through
systematic study of the literature, while Ciano et al. (2019) state that there is a need to
investigate the body of scientific production on Lean in a dynamic way, highlighting the
trends and directions of production research concerning Lean. Hence, there is a need for a
thorough review of empirical literature in the field of LM to identify its present practical
approach and propose future research directions (Jasti and Kodali 2014a). Continually
reviewing writings on Lean ensures that the learning is disseminated to the community of
improvers (Samuel, Found, and Williams, 2015). The present study follows the above
mentioned suggestions for future literature review studies on LM practical implications and
research agenda.

The Systematic Literature Review (SLR) methodology is applied in the present study.
SLR is a fundamental scientific activity which produces a reliable stock of knowledge and
enhanced practice in the management field. Consequently, practitioners and policy-makers
can be provided with a reliable basis to formulate decisions and take action (Tranfield,
Denyer, and Smart 2003). In this context, the present study contributes to the existing body of
LM knowledge by systematically reviewing, firstly, the practical implications of the existing
LM studies, i.e. their valuable insights, messages, guidelines to practitioners with regard to
LM implementation, and secondly, the LM’s future research agenda. More specifically, the
present SLR study groups the many practical implications of the existing LM studies and the
future research suggestions into meaningful themes, and these themes in turn into broad
categories, based on the use of the "affinity diagram" quality tool. In so doing, structured
conceptual frameworks are formulated. Moreover, themes mostly supported in the literature
are identified and specific LM practical and research guidelines are analytically proposed, so
that LM implementation and research can be promoted among practitioners and research
scholars respectively. In other words, the present SLR aims at answering the following
research questions:
RQ1: What are the main themes of the practical implications of the LM studies carried out worldwide so far?

RQ2: What are the main themes of the suggestions for future research in LM proposed by researchers/authors?

Table I summarizes the objectives of previous literature review studies on LM and those of the present study. From this table, it is apparent that the present study goes beyond previous literature reviews on LM, given that their objectives are different from those of this study. Thus, the originality of the present SLR study is strongly supported.

The rest of the paper is divided as follows: in Section 2 the SLR conducted and its phases, are described; the results of the SLR are then analytically presented in Section 3 by describing the profile of the articles reviewed, the practical implications of the studies carried out to date and the future research agenda. In Section 4, the results are discussed, while in Section 5, the conclusions and implications of the present study are presented, along with the limitations of the study and the proposals of the authors for further literature review studies.

2. Methodology

A huge amount of literature exists in numerous databases and journals regarding LM (Samuel, Found, and Williams 2015; Yadav et al. 2017; Onofrei et al. 2019). This body of knowledge, however, is not easily accessible to policymakers and practitioners. Moreover, the process of locating, retrieving and reading the literature is time-consuming for academicians (Thomas et al. 2004). Thus, to achieve the aims of the present study and provide practitioners and academics with useful insights into the practical implications of LM studies and the future research agenda, a comprehensive review of the existing literature of LM was undertaken. It is worth noting that in the field of LM, the existing literature review studies are either traditional or systematic (Table I). A SLR was adopted in the present study for the following reasons. First, a SLR differs from traditional literature reviews as it adopts a more replicable, scientific and transparent process for the literature search and analysis (Tranfield, Denyer, and Smart 2003; Hu et al. 2015; Sangwa and Sangwan 2018b). Second, it provides clearer and more detailed guidance to assist researchers in how to conduct the literature review and present results, and gives a more comprehensive discussion about how to analyse the literature (Hu et al. 2015; Cocca et al. 2019). Third, it minimizes bias and errors providing a review with high-quality evidence and an audit path of the reviewers’ decisions, procedures and conclusions (Tranfield, Denyer, and Smart 2003). Fourth, it has been proven to be adequate for large extensive reviews (Alkhoraif, Rashid, and McLaughlin 2019). Finally, the recent increase in academic interest with regard to SLR studies in the field of Lean (Pinho and Mendes 2017), also stimulated the authors of the present study to conduct a SLR. Examples of recent SLR studies on Lean are those of Leon and Calvo-Amodio (2017), Belhadi et al. (2018), Erthal and Marques (2018), Bortolini et al. (2018), Sangwa and Sangwan (2018a, b), Solaimani et al. (2019), Pagliosa, Tortorella, and Ferreira (2019), Ruben, Vinodh, and Asokan (2019), Dorval, Jobin, and Benomar (2019), Oliveira, Sousa, and Campos (2019), Pearce and Pons (2019), Costa et al. (2019), Henao, Sarache, and Gomez (2019), Dieste et al. (2019), Uriarte, Ng, and Moris (2019) and Cocca et al. (2019).

In the following sections, the stages of the SLR methodology suggested by Tranfield, Denyer, and Smart (2003) and adopted in the present study are presented. Previous SLR studies on LM, e.g. Pinho and Mendes (2017), Erthal and Marques (2018), Cocca et al. (2019), Uriarte, Ng, and Moris (2019) were also conducted based on the methodology of Tranfield, Denyer, and Smart (2003).
<table>
<thead>
<tr>
<th>Authors</th>
<th>Objectives</th>
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</thead>
<tbody>
<tr>
<td>Hasle et al. (2012)</td>
<td>Studying the effects of Lean on the working environment and employee health and well-being, based on publications from 1999 to 2009 (11 articles reviewed).</td>
</tr>
<tr>
<td>Moyano-Fuentes and Sacristan-Diaz (2012)</td>
<td>Exploring the relationships that arise in the research of Lean Production (LP) from the end of the 1980s to 2009 and the directions for future research (163 articles reviewed).</td>
</tr>
<tr>
<td>Powell (2013)</td>
<td>Presenting the most critical areas for further research into the role and implications of ERP (enterprise resource planning) systems in LP, based on the literature published after the year 2000 and up to 2011 (82 articles reviewed).</td>
</tr>
<tr>
<td>Jasti and Kodali (2014a)</td>
<td>Focusing on the research methodologies used in Lean and their related facets as well as the future directions of Lean research, based on publications from 1990 to 2009 (178 articles reviewed).</td>
</tr>
<tr>
<td>Samuel, Found, and Williams (2015)</td>
<td>Studying patterns and trends of literature from 1987 to 2013, that could explain the acceptance of Lean as an operations management philosophy (140 articles reviewed).</td>
</tr>
<tr>
<td>Hu et al. (2015)</td>
<td>Studying the implementation of Lean in small and medium-sized enterprises (SMEs) (key characteristics, implications for practitioners and future areas of research), based on studies published up to the beginning of 2015 (101 articles reviewed).</td>
</tr>
<tr>
<td>Narayananmurthy and Gurumurthy (2016a)</td>
<td>Studying the evolution of the Leanness assessment literature (research objectives and methodologies and potential future research directions) published before January 2014 (53 articles reviewed).</td>
</tr>
<tr>
<td>Negrao, Filho, and Marodin (2017)</td>
<td>Dealing with the degree of adoption of LM practices around the world and the links between those practices and organisation performance, based on studies published between 1993 and 2015 (83 articles reviewed).</td>
</tr>
<tr>
<td>Yadav et al. (2017)</td>
<td>Organizing the existing work on LM in a more structured way and providing insights into LM from the perspective of organizational learning, innovation, and culture, based on studies published up to August 2015 (105 articles reviewed).</td>
</tr>
<tr>
<td>Pinho and Mendes (2017)</td>
<td>Exploring the role of IT in LM contexts, identifying and exploring the main issues approached, and identifying potential future lines of research, based on studies published between 1990 and 2017 (124 articles reviewed).</td>
</tr>
<tr>
<td>Leon and Calvo-Amodio (2017)</td>
<td>Analyzing the interrelationships between Lean and sustainability and their impact on performance from the operational, financial, societal, and environmental viewpoints, based on studies published between 1987 and 2014 (57 articles reviewed).</td>
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<tr>
<td>Authors</td>
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<tr>
<td>Soliman and Saurin (2017)</td>
<td>Identifying how LP has dealt with complexity, both in theory and in practice, from a complexity science perspective, based on studies published up to March 2016 (94 articles reviewed).</td>
</tr>
<tr>
<td>Sangwa and Sangwan (2018a)</td>
<td>Proposing an integrated performance measurement framework to measure the effect of Lean throughout all functions of an organization, based on articles published up to 2016 (66 articles reviewed).</td>
</tr>
<tr>
<td>Bortolini et al. (2018)</td>
<td>Correlating Lean Startup concepts and activities to previous theory and alternative business model validation methods, based on articles published up to early 2018 (118 articles reviewed).</td>
</tr>
<tr>
<td>Sangwa and Sangwan (2018b)</td>
<td>Reviewing various themes of leanness, leanness assessment approaches, leanness assessment areas, and their evolution, based on studies published between 1996 and 2015 (54 articles reviewed).</td>
</tr>
<tr>
<td>Buer, Strandhagen, and Chan (2018)</td>
<td>Investigating the link between Industry 4.0 and LM, based on studies published up to August 2017 (21 articles reviewed).</td>
</tr>
<tr>
<td>Belhadi et al. (2018)</td>
<td>Exploring trends in the research regarding Lean in SMEs, identifying the gaps in the literature, and suggesting future research areas for Lean in SMEs, based on studies published between 1986 and 2018 (118 articles reviewed).</td>
</tr>
<tr>
<td>Erthal and Marques (2018)</td>
<td>Mapping which national culture and organisational culture dimension foster or hinder Lean implementation, based on studies published between 1994 and 2016 (65 articles reviewed).</td>
</tr>
<tr>
<td>Coetzee, Dyk, and Merwe (2019)</td>
<td>Investigating, reporting and interpreting the true, original meaning of the Toyota Way Respect for People (RFP) principles as intended by their creators, based on articles published up to 2015 (17 sources reviewed, including 6 articles).</td>
</tr>
<tr>
<td>Rachman and Ratnayake (2019)</td>
<td>Generating a conceptual framework and revealing research gaps with respect to Lean application in the petroleum industry, based on studies published between 1990-2017 (27 articles reviewed).</td>
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<tr>
<td>Loow (2019)</td>
<td>Investigating how the mining industry has implemented and practices Lean production, based on studies published in the period 2005 - 2016 (20 articles reviewed).</td>
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<tr>
<td>Loh, Yusof, and Lau (2019)</td>
<td>Introducing the Blue Ocean Leadership concept to address leadership issues, based on studies published between 1990 and 2015 (68 articles reviewed).</td>
</tr>
<tr>
<td>Staedele, Ensslin, and Forcellini (2019)</td>
<td>Building knowledge about performance evaluation in Lean production and making suggestions for future scientific research, based on studies published from 2000 to 2018 (67 articles reviewed).</td>
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<tr>
<td>Authors</td>
<td>Objectives</td>
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<tr>
<td>Dorval, Jobin, and Benomar (2019)</td>
<td>Assessing the level of pragmatic ambiguity regarding Lean culture in the manufacturing and service literature, based on articles published up to October of 2016 (1066 sources reviewed, including 678 articles).</td>
</tr>
<tr>
<td>Psomas and Antony (2019)</td>
<td>Identifying the existing literature gaps in LM as well as grouping them into respective themes, based on studies published during 2005–2016 (120 articles reviewed).</td>
</tr>
<tr>
<td>Ruben, Vinodh, and Asokan (2019)</td>
<td>Presenting the state of the art review on Lean and sustainable manufacturing literature focusing on origin, definition, decision-making, performance measurement, product development and application for both Lean and sustainable manufacturing, based on studies published between 1950 and 2017 (820 articles reviewed).</td>
</tr>
<tr>
<td>Pagliosa, Tortorella, and Ferreira (2019)</td>
<td>Identifying the relationships between Industry 4.0 technologies and LM practices, based on studies published between 2010 and 2017 (93 articles reviewed).</td>
</tr>
<tr>
<td>Solaimani et al. (2019)</td>
<td>Conceptualizing an integrative view on Lean innovation management, based on studies published between 1990 and 2016 (80 articles reviewed).</td>
</tr>
<tr>
<td>Oliveira, Sousa, and Campos (2019)</td>
<td>Identifying the barriers faced by LM, formulating a framework to support implementation, and building a model to evaluate what has been done, based on studies published between 2007 and 2018 (75 articles reviewed).</td>
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<tr>
<td>Pearce and Pons (2019)</td>
<td>Reviewing Lean-SEM publication, based on studies published up to December 2015 (52 articles reviewed).</td>
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<tr>
<td>Costa et al. (2019)</td>
<td>Investigating the role played by the human factor in fostering the establishment of a Sustainable Continuous Improvement through LM, based on studies published between 1990 and 2018 (74 articles reviewed).</td>
</tr>
<tr>
<td>Alkhoraif, Rashid, and McLaughlin (2019)</td>
<td>Discussing Lean in SMEs from the perspective of identifying the main challenges faced as well as the Critical Success Factors for Lean implementation within SMEs, based on studies published up to December 2017 (126 articles reviewed).</td>
</tr>
<tr>
<td>Dieste et al. (2019)</td>
<td>Identifying if firms which have applied Lean principles have improved their environmental measures; highlighting the environmental measures that are positively affected by Lean; and finally underlining the most important Lean practices in relation to impacting environmental performance, based on studies published between 1993 and 2018 (72 articles reviewed).</td>
</tr>
<tr>
<td>Hamja, Maalouf, and Hasle (2019)</td>
<td>Reviewing the effect of Lean on productivity and occupational health and safety in the ready-made garment (RMG) industry, based on studies published between 1990 and 2019 (18 articles reviewed).</td>
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<th>Authors</th>
<th>Objectives</th>
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<tr>
<td>Magnani, Carbone, and Moatti (2019)</td>
<td>Addressing the lack of a characterization of the human dimension of Lean, the influence of the human dimension during the Lean adoption process, and its relationship with the technical dimension, based on studies published up to 30 September 2018 (95 articles reviewed).</td>
</tr>
<tr>
<td>Rafique et al. (2019)</td>
<td>Investigating the available Lean implementation approaches, determining the contributions and originalities of previous implementation approaches, examining the types of Lean implementation approaches available and selecting the appropriate type of implementation, scrutinizing the previous methodologies utilised for Lean implementation approaches, selecting the steps/elements required for such an implementation approach, proposing a successful technology combined with Lean implementation approach, based on studies published between 1994 and 2015 (39 articles reviewed).</td>
</tr>
<tr>
<td>Cocca et al. (2019)</td>
<td>Reviewing methods to measure leanness in manufacturing organisations based on studies published up to 31 December 2015 (31 articles reviewed).</td>
</tr>
<tr>
<td>Uriarte, Ng, and Moris (2019)</td>
<td>Identifying the state of the art, existing methods and frameworks for combining Lean and simulation, while also identifying key research perspectives and challenges, based on studies published between 1990 and 2017 (39 articles reviewed).</td>
</tr>
<tr>
<td>Ciano et al. (2019)</td>
<td>Investigating the body of literature on Lean published by the International Journal of Production Research, highlighting the trends and most recent research areas characterising IJPR publications, based on studies published between 2005 and 2018 (529 articles reviewed).</td>
</tr>
<tr>
<td>Yadav et al. (2019d)</td>
<td>Reviewing the implementation of Lean in SMEs and exploring the applicability of Lean thinking in such environments. Analyzing the Lean practices that have been applied in SMEs and the critical success factors for Lean transformation in SMEs, based on studies published up to 2016 (46 articles reviewed).</td>
</tr>
<tr>
<td>Gulyaz et al. (2019)</td>
<td>Examining the problem of working from the internal Lean process point of view, in today’s highly dynamic world, where customer needs get increasingly more sophisticated, based on studies published up to 2018 (49 articles reviewed).</td>
</tr>
<tr>
<td>Rosin et al. (2020)</td>
<td>Highlighting the links between the principles and tools proposed by Industry 4.0 and those proposed by the Lean approach, with a particular focus on how some of Industry 4.0’s technologies are improving the implementation of Lean principles, depending on the technologies’ capability levels, based on studies published up to August 2019 (60 articles reviewed).</td>
</tr>
<tr>
<td>The present study</td>
<td>Identifying themes of practical implications of the LM studies carried out worldwide so far as well as themes of future research suggestions, based on studies conducted from 2010 to 2019 (401 articles reviewed).</td>
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</table>
**Stage I – Planning the review**

Having identified the need for a literature review study in LM, the main phase of this stage includes the preparation and the development of the review protocol (Tranfield, Denyer, and Smart 2003). The authors formed a review team and held meetings to direct the review process. The team then discussed the research problem, identified the previous debates surrounding the field and formulated the research questions based on the objectives of the study. The population of the present study, the search strategy for the identification of relevant studies, the criteria for inclusion/exclusion of studies as well as their quality assessment method were also determined at this stage (Tranfield, Denyer, and Smart 2003).

Nowadays, the most economic and effective way to carry out research is through the use of the internet and databases. However, there has been a proliferation of information – effective and non-effective, authenticated and non-authenticated, reliable and nonreliable, and most importantly useful and non-useful (Bhamu and Sangwan 2014). Following the approach of the literature review studies conducted by Albliwi et al. (2014), Hu et al. (2015), Anthony and Antony (2016), Erthal and Marques (2018) and Alkhoraiif, Rashid, and McLaughlin (2019), only academic journals were considered in the present SLR, while books, online sites and grey literature were excluded. Bearing the above in mind and similar to the literature review studies of Jasti and Kodali (2014a; 2015) and Psomas and Antony (2019), four well-known management science publishers of peer-reviewed academic journal articles, namely, Emerald, Science Direct, Springer and Taylor & Francis, were employed. Due to the limitations presented by incomplete access to several other databases, the search of articles was restricted to these databases. It is worth noting that the literature review studies conducted by Bhamu and Sangwan (2014), Loh, Yusof, and Lau (2019) and Sangwa and Sangwan (2018b) were based on publishers, the vast majority of which are the same as those considered in the present study. In order to further increase the quality of the present SLR and following the approach of Gulyaz et al. (2019), only the journals included in the ABS (Association of Business Schools) 2018 list were considered in the present study. However, in order to avoid missing relevant literature, all the star-journals of the ABS list were considered in the present SLR, while in the study of Gulyaz et al. (2019) only the three and four-star journals were considered. Similar to the literature review studies of Bhamu and Sangwan (2014) and Psomas and Antony (2019), literature review, conceptual, descriptive, exploratory, and empirical papers (including case studies and surveys) were considered in the sample. In order to restrict the search to articles relevant to the scope of this study, inclusion and exclusion criteria were formulated by the review team (Table II).

The last decade was selected for the present SLR following the suggestion of Moghadam, Safari, and Yousefi (2019), according to which future researchers should analyze recent papers to extract the developing and emerging trends in the field of quality management. So, the starting date for the review period of the present study was established as 2010, given that from 2010 onwards the number of LM academic articles increased substantially (Samuel, Found, and Williams 2015; Pinho and Mendes 2017; Erthal and Marques 2018; Henao, Sarache, and Gomez 2019). Moreover, the present study reviews the literature in a subsequent period to the review period considered in the Lean studies of Stone (2012), Moyano-Fuentes and Sacristan-Diaz (2012) and Jasti and Kodali (2014a).
Table II: Inclusion and exclusion criteria for the literature review

<table>
<thead>
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<th>Inclusion criteria</th>
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<tr>
<td>Articles published between 2010 and 2019</td>
<td>Any publication before the year 2010 and after 2019</td>
</tr>
<tr>
<td>Academic journals</td>
<td>Books, online sites and grey literature (conferences, master’s theses, doctoral dissertations, textbooks, reports, working papers from research groups, technical reports, etc.)</td>
</tr>
<tr>
<td>Well-known databases: Emerald Online, Science Direct, Springer Link and Taylor &amp; Francis</td>
<td>Non-academic databases</td>
</tr>
<tr>
<td>Articles published in journals included in the ABS 2018 list</td>
<td>Articles published in journals not included in the ABS list</td>
</tr>
<tr>
<td>Fully accessed articles</td>
<td>Non-fully accessed articles</td>
</tr>
<tr>
<td>Articles studying Lean implementation issues (e.g. Lean principles, practices, tools/techniques, performance, assessment, Leanness)</td>
<td>Articles studying an individual Lean principle, practice or tool/technique; articles studying Lean-Six Sigma, Lean-Agile and Lean-Green implementation issues</td>
</tr>
<tr>
<td>Articles highlighting practical implications and/or future research agenda</td>
<td>Articles not highlighting practical implications and future research agenda</td>
</tr>
<tr>
<td>Articles related to the manufacturing sector</td>
<td>Articles related to the services sector, and construction industry</td>
</tr>
<tr>
<td>The unit of the analysis is the organization itself</td>
<td>The unit of the analysis is the supply chain network</td>
</tr>
<tr>
<td>Articles written in the English language</td>
<td>Articles written in a language other than English</td>
</tr>
</tbody>
</table>

The literature search was based on the following terms: Lean manufacturing, Lean production, Lean principles and practices/tools/techniques in manufacturing. Articles related to specific Lean practices/tools were not taken into consideration since, nowadays, most of the empirical studies consider LM from a multidimensional perspective covering a variety of highly inter-related individual management practices in an integrated system (Camacho-Minano, Moyano-Fuentes, and Sacristan-Diaz 2013). The review team made their decisions with regard to the main phases of this stage by consensus and any significant omissions or oversights resulting from the selection of search terms, time periods, databases were properly addressed. This strengthened the quality of the systematic review process (Hu et al. 2015).

Stage II – Conducting the review
The main phases of this stage were: identification of research, selection of studies, quality assessment, data extraction and monitoring progress and data synthesis (Tranfield, Denyer, and Smart 2003). In order to create the article sample and conduct the systematic review, search strings were constructed based on the search terms identified at the planning stage. An example of a search string included: (Lean) or (Lean manufacturing) or (Lean production) and (principles) or (practices) or (tools) or (techniques) and (manufacturing companies). The search strings were input into the bibliographic databases, resulting in myriads of related articles. Taking into consideration the title, abstract and keywords and, if these were not clear enough, reading the full text, the articles were screened and examined for their fit within the
research focus of the study. The disciplined screening process resulted in a **final sample of 401 articles published in 61 journals (Table III)**, all of which were considered to be relevant. Since the amount of published articles on LM is huge and still growing at a fast pace, it was decided in the present SLR to consider an exhaustive set of data for better introspection and tracing of the LM practical implications and future research (Jasti and Kodali 2015). Hence, the sample size of the reviewed articles (401) as well as journals (61) is amongst the largest ones that have ever been considered in LM review studies (Jasti and Kodali 2015). Similarly, the data sets of the articles considered in the literature review studies of Jasti and Kodali (2015) (546 articles), Dorval, Jobin, and Benomar (2019) (678 articles) and Ciano et al. (2019) (529 articles) were large. The process of article search and selection was checked by the review team while the results were discussed and any disputes over the inclusion and exclusion of studies were resolved during team meetings (Tranfield, Denyer, and Smart 2003; Hu et al. 2015).

**Table III:** The list of journals considered in the present study

<table>
<thead>
<tr>
<th>Journals</th>
<th>Number of articles</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Journal of Production Research</td>
<td>53</td>
<td>0.132</td>
</tr>
<tr>
<td>International Journal of Lean Six Sigma</td>
<td>46</td>
<td>0.115</td>
</tr>
<tr>
<td>Journal of Manufacturing Technology Management</td>
<td>44</td>
<td>0.110</td>
</tr>
<tr>
<td>Production Planning &amp; Control</td>
<td>34</td>
<td>0.085</td>
</tr>
<tr>
<td>International Journal of Operations &amp; Production Management</td>
<td>24</td>
<td>0.060</td>
</tr>
<tr>
<td>International Journal of Productivity and Performance Management</td>
<td>22</td>
<td>0.055</td>
</tr>
<tr>
<td>International Journal of Production Economics</td>
<td>22</td>
<td>0.055</td>
</tr>
<tr>
<td>Total Quality Management &amp; Business Excellence</td>
<td>20</td>
<td>0.050</td>
</tr>
<tr>
<td>Journal of Cleaner Production</td>
<td>16</td>
<td>0.040</td>
</tr>
<tr>
<td>Benchmarking: An International Journal</td>
<td>14</td>
<td>0.035</td>
</tr>
<tr>
<td>The TQM Journal</td>
<td>7</td>
<td>0.017</td>
</tr>
<tr>
<td>International Journal of Quality &amp; Reliability Management</td>
<td>7</td>
<td>0.017</td>
</tr>
<tr>
<td>Journal of Operations Management</td>
<td>7</td>
<td>0.017</td>
</tr>
<tr>
<td>International Journal of Computer Integrated Manufacturing</td>
<td>6</td>
<td>0.015</td>
</tr>
<tr>
<td>Management Decision</td>
<td>5</td>
<td>0.012</td>
</tr>
<tr>
<td>Business Process Management Journal</td>
<td>4</td>
<td>0.010</td>
</tr>
<tr>
<td>Expert Systems with Applications</td>
<td>4</td>
<td>0.010</td>
</tr>
<tr>
<td>Measuring Business Excellence</td>
<td>3</td>
<td>0.007</td>
</tr>
<tr>
<td>Supply Chain Management: An International Journal</td>
<td>3</td>
<td>0.007</td>
</tr>
<tr>
<td>Industrial Management &amp; Data Systems</td>
<td>3</td>
<td>0.007</td>
</tr>
<tr>
<td>Journal of Business Research</td>
<td>3</td>
<td>0.007</td>
</tr>
<tr>
<td>Computers &amp; Industrial Engineering</td>
<td>3</td>
<td>0.007</td>
</tr>
<tr>
<td>Journal of Manufacturing Systems</td>
<td>3</td>
<td>0.007</td>
</tr>
<tr>
<td>The International Journal of Human Resource Management</td>
<td>3</td>
<td>0.007</td>
</tr>
<tr>
<td>Leadership &amp; Organization Development</td>
<td>2</td>
<td>0.005</td>
</tr>
<tr>
<td>Operations Management Research: Advancing Practice through Theory</td>
<td>2</td>
<td>0.005</td>
</tr>
<tr>
<td>Journal of Intelligent Manufacturing</td>
<td>2</td>
<td>0.005</td>
</tr>
</tbody>
</table>

*(Continued)*
The quality of the articles included in the sample was ensured by evaluating the fit between the research methodology used and the respective research questions formulated for the study (Tranfield, Denyer, and Smart 2003; Alblawi, Antony, and Lim 2015). An excel spreadsheet was created to extract general information from the sample articles, including their title, year of publication, journal title, authors, paper type, geographical research area, industry sub-sectors, number of companies or respondents participating in the research study and other features that covered practical implications and future research suggestions.
Practical implications were reported by authors in the LM articles by using statements such as "a manufacturer can better prioritize implementation efforts and resources......", "attention should not only be paid along the production line, but....", "it helps managers overcome difficulties regarding..........", "a platform is provided to practitioners to take appropriate actions............", "the model can be applied to industries.................", etc. On the other hand, future research suggestions were reported using statements such as "there is a need for further research on this subject .....", "it is necessary to continue studying the......", "future research should also consider......", "this is a question that needs to be explored......", "more conceptual and empirical research is needed in order to clarify and validate the.....", etc.

Based on the suggestions of McQuater et al. (1995) and He et al. (1996) and following the approach of Moura Sa and Martins (2016) with regard to quality requirements of consumers as well as the approach of Psomas and Antony (2019) with regard to literature gaps in LM, the quality tool "affinity diagram" was applied to organize and group the large number of the practical implications of the LM studies and future research suggestions. For this purpose, two excel spreadsheets were created, one that included the narrative data of practical implications, and the second, the future research suggestions. Each statement of practical implications or future research was randomly placed in an individual cell. The next step was the grouping of these statements into clusters/themes, based on their affinity or inherent/natural similarity. The final decision for clustering the statements was based on the main element emphasized in each statement. The initial arrangement of these statements into themes, which were labeled according to the content of the respective statements, was reviewed by the team members. Themes supported by few statements were also taken into consideration, since the objective of the authors was to depict every possible dimension of the practical implications and future research of LM. Hence, all data was grouped into meaningful themes and, in turn, these themes into broad categories, from which structured conceptual frameworks were formulated (Chan, Taylor, and Ip 2009). Similarly, Yadav et al. (2017) organized the existing work on LM from the perspective of organizational learning, innovation and culture in a more structured way, enabling practitioners to more easily identify knowledge and best practices and researchers to identify gaps in the extant literature. In the same line, Hu et al. (2015), Buer, Strandhagen, and Chan (2018) and Alkhoraif, Rashid, and McLaughlin (2019), classified LM literature findings into main categories/themes/streams through the exercise of categorising and sub-categorising study findings.

Stage III–Reporting and dissemination
The main aspects of this stage are presenting the report, followed by recommendations and translating this into practice (Tranfield, Denyer, and Smart 2003). Based on the excel spreadsheets developed during Stage II, the “current map” of the collected articles is critically presented and an in-depth look at the practical implications of the LM studies and the future research agenda is provided. This yields a clear picture of the main issues for practitioners, research scholars and academics.

3. Results
3.1 Profile of reviewed articles
Following the approach adopted by Bhamu and Sangwan (2014), Jasti and Kodali (2015), Narayanamurthy and Gurumurthy (2016a) and Abreu-Ledon et al. (2018), Table III presents the distribution of the reviewed articles in the academic journals considered. It is apparent that the majority of the sample articles were published in a limited number of journals. In other words, 14 (23.0%) out of the 61 journals published 322 (80.3%) out of the 401 sample articles.

As far as the diachronic evolution of LM publication is concerned, Figure 1 shows that the number of the published articles increased from 2010 to 2019, while the majority of the sample articles (71.8%) were published from 2016 onwards. It is worth noting that almost half of the sample articles (49.5%) were published in the last two years of the review period, meaning 2018 and 2019. Almost half of the sample articles (49.6%) describe surveys, 31.7% case studies, 13.2% literature reviews and 5.5% conceptual studies (Figure 2). Focusing on the articles describing surveys (199) and the research sample used in each survey, it is apparent that almost half of the surveys (45.2%) were based on a small research sample (<100 companies), while the vast majority of the surveys (81.0%) were based on a research sample that was smaller than 300 (Figure 3). Similarly, focusing on the articles describing case studies (127) and the number of the case organizations studied, it is apparent that the majority of these studies (67.7%) were based on only one case organization. The remaining studies were multi-case studies (Figure 4). Finally, within the articles describing literature review studies (53), it is apparent that the vast majority of them (88.7%) reviewed no more than 200 articles (Figure 5). Excluding the articles which did not specify the manufacturing sub-sectors focused on (183), the manufacturing sub-sectors mostly examined individually in the surveys and case studies are the following: automotive, food/drinks, electrical/electronics, textiles and apparel, machinery, printing/publishing, petro-chemicals, radio, television and communication equipment, basic metals and other minerals, pharmaceuticals, aerospace, plastics and rubber, tyre manufacturing, etc. (Figure 6).

Bearing in mind that the country of the sample industry plays a vital role in LM due to cultural and economic variations (Jasti and Kodali 2014a), the present study further concentrated on analyzing the country of the sample industry by following the approach of Bhamu and Sangwan (2014), Jasti and Kodali (2015), Hu et al. (2015), Negrao, Filho, and Marodin (2017), Sangwa and Sangwan (2018b), Dorval, Jobin, and Benomar (2019) and Henao, Sarache, and Gomez (2019). Excluding the multinational studies (48), it is apparent from Table IV and Figure 7 that the studies (surveys and case studies) of the sample articles were conducted in 44 countries on 6 continents. The majority of these studies were conducted in Asia (36.4%) and Europe (34.3%) (Figure 7). Finally, the countries with the highest number of LM surveys and case studies were India, Brazil, the UK, Italy, the USA, the Netherlands, China, and Sweden (Table IV).
Figure 1: Articles per publication year

Figure 2: Article type

Figure 3: Research studies (surveys) per sample number
Figure 4: "Case study" articles per number of cases

Figure 5: "Literature review" studies per articles reviewed

Figure 6: Studies (surveys and case studies) per manufacturing sub-sector
Figure 7: Studies per continent

Table IV: Geographic research areas

<table>
<thead>
<tr>
<th>Countries</th>
<th>Number of studies</th>
<th>Countries</th>
<th>Number of studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-national</td>
<td>48</td>
<td>Thailand</td>
<td>3</td>
</tr>
<tr>
<td>India</td>
<td>53</td>
<td>South Africa</td>
<td>3</td>
</tr>
<tr>
<td>Brazil</td>
<td>36</td>
<td>Nigeria</td>
<td>3</td>
</tr>
<tr>
<td>UK</td>
<td>23</td>
<td>Ireland</td>
<td>2</td>
</tr>
<tr>
<td>Italy</td>
<td>21</td>
<td>Norway</td>
<td>2</td>
</tr>
<tr>
<td>USA</td>
<td>21</td>
<td>Greece</td>
<td>2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>11</td>
<td>Jordan</td>
<td>2</td>
</tr>
<tr>
<td>China</td>
<td>11</td>
<td>Egypt</td>
<td>2</td>
</tr>
<tr>
<td>Sweden</td>
<td>9</td>
<td>North Africa</td>
<td>2</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>7</td>
<td>Belgium</td>
<td>1</td>
</tr>
<tr>
<td>Malaysia</td>
<td>7</td>
<td>Denmark</td>
<td>1</td>
</tr>
<tr>
<td>Indonesia</td>
<td>6</td>
<td>South Korea</td>
<td>1</td>
</tr>
<tr>
<td>Spain</td>
<td>5</td>
<td>Switzerland</td>
<td>1</td>
</tr>
<tr>
<td>Canada</td>
<td>5</td>
<td>Saudi Arabia</td>
<td>1</td>
</tr>
<tr>
<td>Iran</td>
<td>5</td>
<td>Poland</td>
<td>1</td>
</tr>
<tr>
<td>Australia</td>
<td>4</td>
<td>Pakistan</td>
<td>1</td>
</tr>
<tr>
<td>Portugal</td>
<td>4</td>
<td>Libya</td>
<td>1</td>
</tr>
<tr>
<td>Germany</td>
<td>3</td>
<td>Equador</td>
<td>1</td>
</tr>
<tr>
<td>Turkey</td>
<td>3</td>
<td>R. Macedonia</td>
<td>1</td>
</tr>
<tr>
<td>Hungary</td>
<td>3</td>
<td>Morocco</td>
<td>1</td>
</tr>
<tr>
<td>France</td>
<td>3</td>
<td>Iraq</td>
<td>1</td>
</tr>
<tr>
<td>New Zealand</td>
<td>3</td>
<td>Taiwan</td>
<td>1</td>
</tr>
<tr>
<td>Finland</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.2 Practical implications of the LM studies

Table V presents the output of the "affinity diagram" and, more specifically, the framework describing the themes of the practical implications of the LM studies carried out worldwide. Examples of grouping the practical implications into themes are given in Table A1 of the Appendix. It is apparent that 11 out of the 19 themes revealed concern various aspects of the LM approach itself, and more specifically, in the manufacturing context, waste management, Lean barriers-difficulties, the human factor involved in Lean implementation, Lean training-knowledge, Lean product development, Leanness, Lean assessment framework, implementation guidelines and methodology, company benefits/performance due to Lean, the inter-correlations among Lean practices, Lean implementation issues and Lean definition. The remaining 8 themes of the practical implications concern factors outside the LM approach itself, namely: the countries where LM companies operate, the company sectors and categories, SMEs and large companies, the company's customers, the supply chain, the government, factors affecting Lean implementation, and finally other management approaches/theories integrated with Lean. Figure 8 shows the number of the literature references supporting the themes of practical implications.

Figure 8: The number of the literature references per theme of the practical implications
<table>
<thead>
<tr>
<th>Categories of themes</th>
<th>Themes of practical implications</th>
<th>Supporting references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lean product development</td>
<td>10,127,139,186,202,219,242,246,305,382,420</td>
<td></td>
</tr>
<tr>
<td>Leanness</td>
<td>8,14,46,74,97,107,123,124,168,211,161,182,227,242, 246,249,269,312,316,321,322,324,338,395,396,397, 403,409,423</td>
<td></td>
</tr>
<tr>
<td>Inter-correlations among Lean practices</td>
<td>26,46,88,98,136,150,250,252,288,337,361</td>
<td></td>
</tr>
<tr>
<td>Lean definition</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

(Continued)
3.3 Future research suggestions

Table VI presents the results of the "affinity diagram" and the framework describing the themes of future research suggestions. Examples of grouping the future research suggestions into themes are provided in Table A2 of the Appendix. Taking into consideration the content of the themes revealed, it is apparent that the majority of them (15 out of 22 themes) are related mainly to the LM approach itself, and more specifically, in the manufacturing context, to Lean literature review, theory, future research agenda, barriers/difficulties, knowledge and training, benefits, effects, concept/definition and motivation, waste management, the human factor involved in Lean, Leanness, Lean implementation assessment and measurement, Lean implementation issues and the inter-relationships among Lean elements, Lean implementation guidelines, framework and methodology. On the other hand, the remaining 7 themes for future research include factors outside the LM approach itself, i.e. the supply chain, other management approaches/theories integrated with Lean, the countries where companies operate, sectors, manufacturing sub-sectors and organization units, factors affecting Lean, research methodologies and the research sample size. Figure 9 shows the number of the literature references supporting the themes of future research suggestions.

<table>
<thead>
<tr>
<th>Categories of themes</th>
<th>Themes of practical implications</th>
<th>Supporting references</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMEs - Large companies</td>
<td></td>
<td>3,7,11,44,45,52,75,103,105,116,119,148,166,188,224,236,238,291,293,298,300,311,313,315,338,390,391,392,399,412,413,414,415</td>
</tr>
<tr>
<td>Customers</td>
<td></td>
<td>60,90,113,149,163,225,366,418</td>
</tr>
<tr>
<td>Supply chain</td>
<td></td>
<td>1,6,56,60,90,105,113,169,188,195,208,239,390,393,414,418</td>
</tr>
<tr>
<td>Government</td>
<td></td>
<td>16,187,232,290,323,392</td>
</tr>
<tr>
<td>Categories of themes</td>
<td>Themes of future research suggestions</td>
<td>Supporting references</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Lean literature review</td>
<td>96,118,172,201,208,221,253,289,290,309,318,321,348,353,391</td>
<td></td>
</tr>
<tr>
<td>Lean theory</td>
<td>172,174,199,328,385</td>
<td></td>
</tr>
<tr>
<td>Lean future research agenda</td>
<td>172</td>
<td></td>
</tr>
<tr>
<td>Waste management</td>
<td>6,20,48,53,71,91,146,172,367,358</td>
<td></td>
</tr>
<tr>
<td>Lean barriers</td>
<td>39,53,105,125,126,165,167,170,175,220,221,222,299,300,320,341,345,349,361,370,418,419</td>
<td></td>
</tr>
<tr>
<td>Lean benefits</td>
<td>3,25,42,49,66,78,166,220,245,248,283,343,345</td>
<td></td>
</tr>
<tr>
<td>Leanness</td>
<td>8,14,33,46,74,123,137,161,182,211,242,248,249,316,321,336,338,360,395,397,400,403,409,423</td>
<td></td>
</tr>
<tr>
<td>Lean implementation guidelines, framework and methodology</td>
<td>7,10,29,30,36,39,54,55,63,70,95,100,103,133,136,162,165,173,175,176,180,182,185,186,195,201,232,239,251,261,274,278,281,308,309,320,322,323,345,349,356,361,383,385,402,420</td>
<td></td>
</tr>
<tr>
<td>Lean concept/definition</td>
<td>18,25,89,90,147,199,201,361</td>
<td></td>
</tr>
<tr>
<td>Lean motivation</td>
<td>361</td>
<td></td>
</tr>
</tbody>
</table>

(Continued)
Table VI: (Continued)

<table>
<thead>
<tr>
<th>Categories of themes</th>
<th>Themes of future research suggestions</th>
<th>Supporting references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply chain</td>
<td>1,3,90,102,106,135,156,166,169,224,225,242,245,248,265,283,284,324,325,360,364,405</td>
<td></td>
</tr>
</tbody>
</table>
4. Discussion

4.1 Profile of the reviewed articles

A range of meaningful insights are gained from the profile of the articles reviewed. Taking into consideration the number of the sample articles as well as the number of the journals which have published these articles, the Pareto principle 80/20 is reflected. So, the "vital few" journals which have published the majority of the LM articles are clearly distinguished from the "useful many" which have published the minority of these articles. In other words, the former can be considered as more LM oriented journals than the latter. Thus, authors wishing to conduct future studies on LM can base them firstly on these "vital few" journals.

**Figure 9:** The number of the literature references per theme of future research suggestions.
The "vital few" journals publishing many LM articles are also presented in the literature review studies of Jasti and Kodali (2014a; 2015), Yadav et al. (2017), Oliveira, Sousa, and Campos (2019) and Psomas and Antony (2019). The journals found to have published the majority of the LM articles are also among the top journals of the literature review studies of Jasti and Kodali (2014a; 2015), Bhamu and Sangwan (2014), and Narayananmurthy and Gurumurthy (2016a), Belhadi et al. (2018), Dorval, Jobin, and Benomar (2019), Ruben, Vinodh, and Asokan (2019) and Psomas and Antony (2019). None of the above mentioned studies have specifically highlighted the application of the Pareto principle to the journals publishing LM articles, except for the study of Psomas and Antony (2019) which does identify the application of the Pareto principle per publisher.

The diachronic increase of the LM articles reviewed in the present study is also observed in the literature review studies of Narayananmurthy and Gurumurthy (2016a), Erthal and Marques (2018), Sangwa and Sangwan (2018b), Henao, Sarache, and Gomez (2019), Dieste et al. (2019), Psomas and Antony (2019), Pagliosa, Tortorella, and Ferreira (2019), Staedele, Ensslin, and Forcellini (2019), Ruben, Vinodh, and Asokan (2019) and Uriarte, Ng, and Moris (2020). The several manufacturing sub-sectors participating in the surveys and case studies of the sample articles, confirm the wide applicability of LM throughout the manufacturing sector. It is also worth noting that the manufacturing sub-sectors mostly examined in the surveys and case studies were also examined by Moyano-Fuentes and Sacristan-Diaz (2012), Jasti and Kodali (2015), Narayananmurthy and Gurumurthy (2016a), Negrao, Filho, and Marodin (2017), Psomas (2018) and Psomas and Antony (2019).

In the present study, similar to the literature review of Jasti and Kodali (2015), Asia and Europe were the continents where the majority of the LM surveys and case studies were conducted, while in the literature reviews of Dorval, Jobin, and Benomar (2019) and Alkhoraif, Rashid, and McLaughlin (2019), North America and Europe were the continents with the majority of the LM surveys and case studies. The top five countries where the LM surveys and case studies of the present SLR were conducted include India, Brazil, the UK, Italy and the USA. These countries are also among the top countries where the LM surveys and case studies reviewed by Jasti and Kodali (2014a) and Negrao, Filho, and Marodin (2017) were conducted.

### 4.2 Practical implications

The two broad categories of practical implications themes, i.e. those concerning LM itself and those concerning factors outside LM, can be considered as categories pertaining to the internal and external nature of LM respectively. The practical implications themes which reflect the internal nature of LM concern issues with regard to the pre-implementation phase (e.g. Lean definition, barriers-difficulties, training-knowledge, guidelines and methodology, the human factor needed), the implementation phase itself (e.g. waste management, implementation issues, product development, the inter-correlations among LM practices) and the post-implementation phase (e.g. Leanness, benefits) of Lean in the manufacturing sector (Bhamu and Sangwan 2014). On the other hand, the practical implications themes of the external nature of LM are related to a company’s context (e.g. its size, sector, customers, supply chain, internal influencing factors), the diverse managerial systems available and the external environment of a company’s sector (e.g. the country where the company operates in and its respective government).

The structure of the practical implications themes is similar to that revealed considering only the research articles of the sample. It is also similar to the structure of the
themes which is shown considering only the case studies and the literature review articles. In other words, in each theme, there are practical implications from articles describing research studies, case studies and literature review studies.

Moreover, the structure of the themes of practical implications revealed from all the LM articles of the sample is similar to the structure of themes considering only LM articles from North and South America. This is also similar to the structure of the themes considering only LM articles from Europe and the structure of the themes considering only LM articles from Asia. This suggests that, in each theme, there are practical implications from articles studying LM in America, Europe and Asia.

Taking into consideration all the articles reviewed, it is apparent that the practical implications themes regarding the internal nature of LM are supported in the literature (493 references) more than those concerning its external nature (302 references). Moreover, the themes which are supported by most references (Figure 8) corresponded to: human factors, company benefits/performance, Lean implementation issues and other management approaches/theories integrated with Lean. Thus, practitioners can firstly focus their efforts for the improvement of LM implementation on these practical implications.

In line with the present study, the literature review of Hu et al. (2015) which focused specifically on SMEs and the literature review of Yadav et al. (2017) which focused on LM from the perspective of organizational learning, innovation and culture, also revealed some practical implications concerning both the LM approach itself and factors outside it, without however covering the extent of the themes of the practical implications presented in this SLR.

4.3 Future research agenda

In line with the broad categories of practical implications themes, the two broad theme categories for suggested future research include themes concerning LM itself and themes concerning factors outside the LM approach. The themes concerning LM itself reflect the internal nature of LM, i.e. the pre-implementation phase (e.g. literature review, theory, future research agenda, barriers/difficulties, knowledge and training, concept/definition, motivation, human factors, implementation guidelines, frameworks and methodology), the implementation phase itself (e.g. waste management, implementation assessment/measurement and issues and the inter-relationships among LM elements) and the post-implementation phase (e.g. Leanness, benefits and effects) of LM in manufacturing environments (Bhamu and Sangwan 2014). The themes for suggested future research from the external aspect of LM refer to the company (e.g. its sector, supply chain, internal influencing factors), the country where the company operates, the diverse managerial systems/theories available and the methodological research approach and sample size.

The future research structure is similar to that considering only the research, case studies and literature review articles of the sample. In other words, in each theme, there are future research suggestions from articles presenting research studies, case studies and literature review studies. Moreover, this structure is similar to the structure of themes exposed considering only LM articles from North and South America. It is also similar to the structure of the themes which is revealed considering only LM articles from Europe and to the structure of the themes revealed considering only LM articles from Asia. In other words, in each theme, there are future research suggestions from articles studying LM in America, Europe and Asia.
Taking into consideration the literature references supporting the future research suggestions of the two broad categories of themes, it is apparent that the broad category concerning factors outside the LM approach (pertaining to the external nature of LM) is supported by more references (559) than the broad category concerning the LM approach itself (pertaining to the internal nature of LM) (438 references). Moreover, based on the literature references supporting the future research themes of LM, research areas of high priority are defined as: sectors, manufacturing sub-sectors and organization units, the research methodologies used, Lean effects, countries, and the human factor involved in Lean (Figure 9). Thus, researchers and academics can firstly focus on these themes mostly supported in the literature and follow the specific future research suggestions. It is also worth noting that, although many LM studies have already been conducted in many manufacturing sub-sectors (Figure 6) and countries of Asia, Europe and South and North America until now (Table IV, Figure 7), the present SLR revealed that future research should be further conducted on several manufacturing sub-sectors of these continents, and more specifically on companies operating in both developed and developing economies that are characterized by a different cultural and economic status.

Future research suggestions reflecting the two broad categories of themes mentioned above have also been presented in literature review studies published so far. However, no previous study has presented the future research suggestions thoroughly, meaning in a structured framework consisting of suggestions-themes-categories, as it is formulated in the present study. Unlike the present SLR, the vast majority of the future research suggestions presented in the studies of Bhamu and Sangwan (2014) and Narayanamurthy and Gurumurthy (2016a) concerned the internal nature of the LM approach, while those of the literature review studies of Jasti and Kodali (2014a), Hu et al. (2015) and Buer, Strandhagen, and Chan (2018) concerned mostly the external nature of LM. On the other hand, the studies of Moyano-Fuentes and Sacristan-Diaz (2012), Jasti and Kodali (2015), and Erthal and Marques (2018) provided, similarly to the present SLR, a more balanced distribution of future research suggestions between the two broad categories mentioned above.

5. Conclusions, limitations and agenda for future studies
A number of authors and experts in the field of Lean support the view that there is a dearth of thorough SLR studies which emphasise its practical implications and future research agenda. Thus, we were strongly motivated to systematically review the literature, setting objectives which were substantially different from those of previous literature review studies on LM. Moving a step further than simply presenting the large number of the practical implications of the existing LM studies and the future research suggestions, an "affinity diagram" was applied and respective structured conceptual frameworks were formulated. Thus, a meaningful and summarized picture of practical implications and future research suggestions is provided. From the above it is apparent that the present SLR fills a literature gap and extends our knowledge by:

- Providing significant and original insights into LM, from both practical and academic perspectives, to establish the practical implications of LM studies carried out worldwide and identify novel research streams.
- Providing practitioners with a general overview of LM so they can develop a more robust knowledge of this approach and its characteristics, to help them formulate more effective strategies for its deployment.
Structuring and defining potential research topics for LM, which in turn can stimulate researchers to further study certain issues in depth, leading to a better understanding of the dynamics of implementing LM.

The Pareto principle is reflected based on the published LM articles and the respective journals considered in the present SLR. This means that the "vital few" journals contributed mostly to the evolution of the LM publication, which increased in the last years of the last decade. Confirming the existing literature, India, Brazil, the UK, Italy and the USA were the top countries where LM research had been carried out.

Based on the structured conceptual frameworks that present the themes of practical implications and future research suggestions, a similar picture emerges. More specifically, two broad categories of themes are identified, namely the LM approach itself (pertaining to the internal nature of LM) and factors outside the LM approach (pertaining to the external nature of LM). With regard to the former, the pre-implementation, implementation and post-implementation phases of Lean in manufacturing are identified. With regard to the latter, the following issues are determined: the company’s context, the diverse managerial systems available, the country where the company operates and its respective government and the methodological research approach.

The broad category of practical implications themes concerning the LM approach itself is supported in the literature more than the broad category of themes concerning factors outside the LM approach. By contrast, the broad category of future research themes concerning factors outside the LM approach is supported in the literature more than the broad category of themes concerning the LM approach itself. The themes of practical implications which are supported by most literature references concern the human factor, company benefits/performance, Lean implementation issues and other management approaches/theories integrated with Lean. On the other hand, the themes of future research supported mostly in the literature are related to sectors, manufacturing sub-sectors and organization units, the research methodologies used, Lean effects, countries, and the human factor involved in Lean.

Studies, including literature reviews, suffer from limitations and the present study is no exception. The main limitation of the present SLR is that only four academic publishing houses were used for article collection, excluding some significant publishers. The exclusion of books, online sites and grey literature (e.g. conferences, master’s theses, doctoral dissertations, textbooks and working papers) is also a limitation of the present SLR. The articles were also reviewed based on only two topics, namely the practical implications and the future research agenda. Excluding studies examining an individual Lean practice or tool/technique and studies related to Lean-Six Sigma, Lean-Agile manufacturing and Lean-Green management may conceal significant practical implications and future research suggestions. Moreover, excluding the supply chain network as well as the services, the public and the construction sector is also a limitation of the present SLR. Finally, the subjectivity in applying the "affinity diagram", and more specifically, the subjectivity of grouping the large number of practical implications and future research suggestions based on their affinity is an issue that should be carefully considered while utilizing the present study findings.

Based on the above limitations, future literature review studies can be designed. For example, it is strongly suggested that a SLR study be carried out on LM based on more academic publishing houses than those used in the present study, books and grey
literature as well. SLR studies should consider articles examining not only LM as an integrated system but individual Lean practices or tools/techniques. Future literature review studies on the practical implications and the research agenda of LM should also consider the supply chain network of a company as well as the service business environment. Focusing on the practical implications and the research agenda of Lean and Six Sigma, Lean and Agile manufacturing and Lean and Green management is also an interesting avenue for future literature review studies. The above suggested future literature review studies can also further analyze the practical implications and future research of LM by supporting the respective themes by distinct theories and formulating casual relationships among them. In so doing, academics and practitioners will be provided with a clearer picture with regard to the LM practical implications and future research. It is also worth taking into consideration the suggestion of Ansari, Fiss, and Zajac (2010) for further study in the field of LM. More specifically, reviewing the literature and studying the dynamic fit between LM practices and the adopting organization and how this fit is influenced by technical, cultural, and political factors would open up an interesting new avenue for future research.
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deletion with lean and sustainable supply chain management." *International Journal of


heterogeneity." *International Journal of Productivity and Performance Management*

environmental complexity, and productivity: A mediated moderation model." *Journal of
<table>
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<tr>
<th>Themes</th>
<th>Practical implications</th>
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<tr>
<td>Waste management</td>
<td>Attention to the importance of searching for and eliminating muda (waste) should not only be paid along the production line, but also inside the information flow (Bevilacqua, Ciarapica, and Paciarotti 2015); to reduce waste and diagnose problems and their solutions, managers must undertake three interlinked tasks, which are of equal value to all kinds of product and manufacturing and service processes: the elimination of obvious waste, the reduction of variability to transform buffers into obvious waste, and the balancing of the remaining buffers to best achieve performance targets (Thurer, Tomasevic, and Stevenson 2016); addressing how value, value-adding and waste are conceived and used in operational work processes, four ideal types of enactment have been identified: the well-tuned - mechanistic and rule-based, the cumbersome - mechanistic and reflective, the coercive - complex and rule-based, and the enabling - complex and reflective (Johansson and Osterman 2017); the combined application of VSM, plant layout, fuzzy QFD and fuzzy FMEA is used to prioritise the critical resources in relation to identified wastes (Kumar and Parameshwaran 2018).</td>
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<td>Lean barriers - difficulties</td>
<td>The RFID-based LM (an automatic identification system with attributes such as operational visibility, inventory control, production control, minimized lead times and the real-time data information) could be of great help in handling barriers affecting Lean implementation in the operational, managerial and financial regimes (Rafique et al. 2016); based on the framework consisting of sufficient management time and training for employees, development of a right culture, development of effective communication, carrying out low-cost production, and obtaining external funding, practitioners can prioritize Lean barriers and overcome many problems, especially those related to resource allocation in Lean implementation (Zhang, Narkhede, and Chaple 2017); there are several ways (such as softening the impact on financial performance, gradually adjusting the control system, combining different control orientations, finding alternative ways to safeguard the reliability of accounting information) to mitigate the constraints that may arise from incompatibilities between accounting-based controls and Lean controls (Steen and Tillema 2018); go more often to the shopfloor to try to find out the source of problems rather than looking at periodical reports (Chiarini, Baccarani, and Mascherpa 2018).</td>
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<tr>
<td>Human factor involved in Lean</td>
<td>Social culture impacts the investments in Lean practices, therefore managers need to encourage informal conversations among employees in the plant as a form of sharing knowledge and organise events where people can openly discuss their experiences (Onofrei et al. 2019); human factors and ergonomics in Lean implementation influence workers' quality of life and organizational performance positively and also lead to healthy organizations for workers and management (Nagaraj et al. 2019); LM should focus on the participation of employees, their safety and hierarchy and on regulating and balancing their stress (Stimec and Grima 2019); efficient communication between management and workers, in such a manner that the administration pays attention to the way in which they speak with workers' representatives, workers are glad to acknowledge the management recommendations and workers feel more energized and enabled in doing Lean ventures (Singh and Singh 2019).</td>
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<td>Themes</td>
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<tr>
<td>Lean training-knowledge</td>
<td>Lean knowledge objects should be contextually grounded for operations management and applied services interface environments, which could reduce the danger of complying with irrelevant production-based Lean and the misuse of scarce resources (McAdam et al. 2016); Lean educators and consultants should incorporate into their Lean training, materials such as a deeper understanding of the impact of variability on flow, an explicit recognition of the impact of job characteristics (task significance, task identity, skill variety, autonomy and feedback) on worker satisfaction and motivation (Hopp 2018); Lean-focused regular conferences can especially strengthen managers’ participation in transfer coalition and demonstrate their acceptance of the Lean culture (Demeter and Losonci 2019); companies that are more aware of LP implementation will better foster learning and knowledge sharing at all organisational levels by encouraging practices related to employees’ involvement and problem-solving (Tortorella et al. 2019d).</td>
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<td>Lean product development</td>
<td>The efforts to implement concurrent engineering increase three Lean product development problems (project leader without formal authority, lack of communication and feedback and no information technology integration) (Tortorella et al. 2016); Taguchi’s Quality Philosophy and Practice is an effective competitive product deployment strategy (low cost but high quality) that Lean organisations can use to differentiate themselves from their competitors (Gamage, Jayamaha, and Grigg 2017); the Lean Product Development framework (strategies and portfolio, project management, needs and requirements, concept system, detailed project, testing and validation, manufacturing product launch, monitoring and discontinuity) supports a sustainable inclination to the product life cycle and more efficient execution of the manufacturing processes and also predicts the possibility of developing optimized products and eliminating waste in manufacturing companies (Lermen et al. 2018); a systematic implementation of both Lean product development and LM is suggested, rather than following the more common isolated approach (Marodin et al. 2018).</td>
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<tr>
<td>Leanness</td>
<td>The Leanness of the organization can be measured in the areas of manufacturing process, NPD, finance, administration, customer management, and supplier management using KPIs categorized as qualitative or quantitative, strategic or operational, social or technical, financial or non-financial, leading or lagging, static or dynamic (Sangwa and Sangwan 2018a); the Leanness assessment can be performed at three levels: at the first level, the assessment area of manufacturing process, NPD, finance, HRM, administration, customer, and supplier needs to be evaluated, at the next level, the performance dimensions of the above-mentioned assessment areas need to be identified and at the last level, KPIs assessing the performance dimensions should be evaluated (Sangwa and Sangwan 2018b); focus on cultivating an organizational culture that promotes openness to new ideas and drives organizational efforts toward the objective of Leanness since it has beneficial impacts on both business and operational performance (Sahoo 2019); managers should avoid taking a myopic view of inventory Leanness management, that maintaining moderate inventory Leanness is able to improve the likelihood of survival, yet firms should not adopt excessive Leanness management in the manufacturing, while well-managed inventory can bring a massive competitive advantage to firms (Wang, Lin, and Shi 2019).</td>
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<th>Themes</th>
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<tr>
<td>Lean assessment framework, implementation guidelines and methodology</td>
<td>The assessment method of Lean transformation including basic ability (LT planning ability, LT resource allocation ability, LT operation ability), process power (LT incentive, external force of LT, grassroots force of LT, senior management force of LT), result for the transformation (the ability of Lean principles and methods, the ability of Lean value delivery, the speed of Lean performance improvement) has certain rules in the aspects of Lean strategy planning (Liu et al. 2017); the following Lean practices can be used: Kaizen, HRM, Supplier JIT, Pull, Cell manufacturing, TPM, Supplier development, Flow, SMED, Customer involvement, Poka yoka, Heijk, VSM, Standardization, SS, Takt, NPD, Inventory management (Negrao, Filho, and Marodin 2017); the following principles can be used for LM in projects: set the vision, embrace emergence, eliminate waste, create an improved flow of tasks, improve continuously (Holweg and Maylor 2018); the main criteria of the LM framework include shopfloor management, manufacturing strategy, quality management, manufacturing process, supplier and customer management, workforce management (Yadav et al. 2020).</td>
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<tr>
<td>Company benefits and performance due to Lean</td>
<td>The higher the adoption of Lean practices, the better the control over inventory, waste minimisation, timely deliveries, demand management, cost reduction and productivity (Panwar et al. 2018); it is possible to implement only a few sets of Lean bundles to obtain successful financial performance (e.g. TQM, JIT) (Galeazzo and Furlan 2018); the adoption of LM practices enables organisations to achieve significant and simultaneous performance improvements in terms of operational, financial and environmental measures, and the S-shaped form of the relationship between LM and business performance implies that the positive and significant relationship between Lean practices and business performance will continue until a point at which the adoption of further practices will not bring further positive changes in business performance (Negrao et al. 2019); investments in Lean practices have a higher payoff rate in terms of operational performance, when the company is also increasing their structural capital levels (Onofrei et al. 2019).</td>
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<tr>
<td>Inter-correlations among Lean practices</td>
<td>The multi-faceted nature of Lean highlights the need for managers to focus attention on the interactions and relationships of the core dimensions of Lean which make it work effectively (Taylor, Taylor, and McSweeney 2013); Lean practices should be holistically implemented because all the practices are interdependent and equally important (Nawanir, Teong, and Othman 2013); the implementation of an individual Lean practice may improve the contribution of other existing practices (Nawanir, Lim, and Othman 2016); through the relationship between the implementation of hard and soft Lean practices and the physical work environment and job characteristics, a system is provided to check how the social and technical components of LM evolve over time (Gaiardelli, Resta, and Dotti 2019).</td>
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<td>Lean implementation issues</td>
<td>Thoroughly implement a manageable number of Lean practices instead of superficially implementing a multitude of techniques (Moldner, Garza-Reyes, and Kumar 2018); an increase in the depth of LM implementation on the shopfloor is likely to spread Lean principles to other parts of the organization (Marodin et al. 2018); managers should increase attention to resource allocation and make decisions that, instead of trying to integrate as many Lean bundles as possible in their managerial system, wisely focus on only a few but complementary Lean bundles that better fit their context (Galeazzo and Furlan 2018); if the organisation is more advanced in Lean, it should focus on creating consistency in the different projects and develop a more mature improvement structure (Knol et al. 2019).</td>
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<th>Themes</th>
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<td>Lean definition</td>
<td>Due to the indistinct definitions of Lean, one should use the concept of Lean with care (Arlbjorn and Freytag 2013).</td>
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<tr>
<td>Countries</td>
<td>European pharmaceutical manufacturing firms still require further development in areas such as processes, planning and control, human resources, top management and leadership, customer relations, and supplier relations, if they are to effectively support or sustain LM (Garza-Reyes et al. 2018b); organisations located in countries culturally similar to Japan should not assume that it will be easy to implement Lean, just as organisations in countries different from Japan should not relinquish the idea of implementing it (Erthal and Marques 2018); in central India-based manufacturing industries the effective Lean implementation can be done only by creating a supportive environment, having regular training, implementing awareness programs and developing a Lean-based culture to avail the full potential of LM, which ultimately leads to improved overall productivity (Dave and Sohani 2019); greater involvement of consultants, training academies and collaborative working with experts from India and abroad is needed for LM implementation in India (Rajagopalan and Solaimani 2019).</td>
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<tr>
<td>Company sectors and categories</td>
<td>Besides organizational factors such as structure, remuneration, and change agent, sector specific factors such as product perishability, behavior of the retailer, traditional production process, and layout play significant roles in Lean implementation in the food sector (Dora, Kumar, and Gellynck 2016); determining factors driving sustainable performance through the application of Lean management practices in horticultural primary production include knowledge, workforce and training, operational context, organizational structure, alignment, integration, prioritization, technology and decision support, nature of the process, product and plant (Pearce et al. 2018); Lean methods and tools influence the environmental performance of organisations of other sectors, besides manufacturing, such as logistics and transport, healthcare, services (Garza-Reyes et al. 2018a); increased inventory Leanness could help members of the value-added wood products industry to achieve better financial performance and increase their profitability (Tasdemira and Hiziroglu 2019).</td>
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<td>SMEs - Large companies</td>
<td>SME owners/managers may need to consider the involvement of external professionals to overcome the employee barriers in their Lean journey (Ramadas and Satish 2018a); SMEs could take advantage of the opportunities offered by the adoption of Lean practices to pursue their product and process innovation strategies (Shashi et al. 2019); the use of all Lean practices is not necessary or desirable in SMEs, and only some of the most suitable practices should be employed on the basis of the production and management characteristics (Yadav et al. 2019d); the Critical Success Factors, namely policy, leadership and management, understanding, implementation and monitoring, culture, humans and competencies, funding, technique and communication, market, customers and suppliers, influence the success of Lean in SMEs (Belhadi, Touriki, and Elfekazi 2019).</td>
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<td>Themes</td>
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<td>Customers</td>
<td>Managing and developing strategic relationships with buyers in LM contexts is strongly suggested (Chavez et al. 2015); companies need to further exploit Lean practice bundles related to customers, along with HRM practice bundles, if not already in place (Birkie 2016); the Lean customer relationship may be a path imposed by the customer, or even a strategy to gain customer fidelity (Marodin et al. 2017).</td>
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<td>Supply chain</td>
<td>Managing and developing strategic relationships with suppliers in LM contexts is strongly suggested (Chavez et al. 2015); use the framework consisting of technical Lean practices, human Lean practices, incremental process innovation, radical process innovation, operational performance as a template to conduct internal benchmarking studies with key performance indicators between different suppliers (Moldner, Garza-Reyes, and Kumar 2018); if an organisation is more advanced in Lean terms, managers should focus on the supplier link (Knol et al. 2018); involve suppliers in the process of implementing Lean practices (Dieste et al. 2019).</td>
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<td>Government</td>
<td>The weaknesses of the Kuwaiti manufacturing SMEs can be used by the government to formulate some action points regarding LM (AL-Najem et al. 2013); the correlation among internal, external and policy drivers will enable the policy makers in government and industry to strategically leverage the resources for the successful implementation of Lean in the industry (Sangwan, Bhamu, and Mehta 2014); the framework for Lean thinking on the strategic and the operational levels including knowing, understanding and thinking Lean may give organisations and governments – that have (or plan) programmes such as the Lean Agriculture programme – constructive ideas on how to structure and/or adapt their programmes (Melin and Barth 2018); governments and/or economic decision makers, who have an interest in seeing national firms grow, should be ready to give incentives and finance all the Lean efforts (Valente, Sousa, and Moreira 2019).</td>
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<td>Factors affecting Lean implementation</td>
<td>Lean practices are negatively influenced by product mix variety and innovation, while positively influenced by time effectiveness variables (Bevilacqua, Ciarpica, and Sanctis 2017b); pre-existent complexity attributes that are likely to support Lean and be increased by it (e.g. daily meetings and other social interactions between leaders and their teams) could only be a target for refinement, reducing the need for starting the implementation of new Lean practices from scratch (Soliman, Saurin, and Anzanello 2018); standards development, managerial versatility, organizational focus, supportiveness, capability development, basis of performance evaluation, affect LM implementation (Camuffo and Gerli 2018); the quality-related design principles should play an explicit role in any Lean programme (Roth, Deuse, and Biedermann 2020).</td>
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<td>Lean integration with other management approaches/theories</td>
<td>Changeableness in Lean Production is increased for workstations through the interface between Lean Production and Cyber Physical Systems and technologies from software engineering (Kolberg, Knobloch, and Zühlke 2017); use the framework consisting of technical Lean practices, human Lean practices, incremental process innovation, radical process innovation, operational performance, for self-assessments of LM and innovation capability (Moldner, Garza-Reyes, and Kumar 2018); cost, flexibility, productivity, quality, reduced inventory and reliability are all performance metrics which are affected through an Industry 4.0 and LM integration (Buer, Strandhagen, and Chan 2018); the most improved Lean principles through Industry 4.0 are those related to the themes of Just-in-time and Jidoka, while the least improved are those related to the themes of waste reduction and people and teamwork (Rosin et al. 2020).</td>
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Table A2: Examples of grouping the future research suggestions into themes

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<th>Themes</th>
<th>Future research suggestions</th>
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<tr>
<td>Lean literature review</td>
<td>A thorough review of the degree of Lean adoption by industry sector and the relationship of these practices with organisational performance, enlarging the set of available information (keywords, databases, language of the articles and criteria of inclusion and exclusion) through systematic study of the literature (Negrao, Filho, and Marodin 2017); Lean quantitative studies (through meta-analysis) and the Lean culture assessment instruments (Dorval, Jobin, and Benomar 2019); articles, dissertation theses, working papers and conference proceedings with regard to Lean (Ruben, Vinodh, and Asokan 2019); the features of IJPR research on Lean compared to the other journals’ studies, an analysis that involves the network of the keywords of the literature reviews (Ciano et al. 2019).</td>
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<td>Lean theory</td>
<td>Analyse Lean theory from the perspective of other theories on systems functioning (e.g. system dynamics, systems engineering and soft systems methodology) (Saurin, Rooke, and Koskela 2013); build and verify Lean theory (Jasti and Kodali 2014a; Jasti and Kodali 2015); treat the variation between rhetoric and practice as a separate phenomena (Langstrand and Drotz 2016).</td>
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<tr>
<td>Lean future research agenda</td>
<td>Propose future research directions (Jasti and Kodali 2014a).</td>
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<td>Waste management</td>
<td>Study metrics of the individual seven wastes and total amount of wastes (Narayananurthy and Gurumurthy 2016a); the interrelationship between the different types of buffers (waste that cannot be reduced without creating another form of waste) (Thurer, Tomasevic, and Stevenson 2016); the formulation of an enhanced Lean waste prioritization model (Sutrisno et al. 2018); resource wastes and their effect on organizational productivity (Goshime, Kitaw, and Jilcha 2019).</td>
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<td>Lean barriers/difficulties</td>
<td>Study the main barriers of LM implementation (Bevilacqua, Ciarapica, and Sanctis 2017b); the issues connected to barrier factors and extract the variables associated with these factors (Ramadas and Satish 2018a); the impact of Lean barriers on the company's business performance (Sanctis, Mere, and Ciarapica 2018); the national culture dimensions that hinder Lean (Erthal and Marques 2018).</td>
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<td>Lean knowledge, training</td>
<td>Study the moderating effect of the students' learning preferences (Index of Learning Styles) on the assertiveness of the LM teaching method (Tortorella and Cauchick-Miguel 2018); the transfer of Lean knowledge within subsidiaries and the headquarters of the same company (Demeter and Losonci 2019); the important role of training as a Lean job resource (Beraldin, Danese, and Romano 2019); how effectively Lean practices are being adopted and implemented, particularly in the case of transferring the knowledge (Lean transformation) (Abu et al. 2019).</td>
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<tr>
<td>Lean benefits</td>
<td>Determine the outcomes of Lean in the long term (Camacho-Minano, Moyano-Fuentes, and Sacristan-Diaz 2013); the benefits of Lean across a full range of sustainability issues (Piercy and Rich 2015); the benefits associated with different mechanisms of Lean transfer (Boscarri, Danese, and Romano 2016); the benefits attained by the small incremental Lean manufacturing activities and the factors affecting those benefits (Singh, Singh, and Singh 2018).</td>
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<tr>
<th>Themes</th>
<th>Future research suggestions</th>
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<tr>
<td>Human factor involved in Lean</td>
<td>Study the cultural differences that may affect employees’ perceptions about Lean implementations in distinct social and organizational cultures (Pakdil, Toktaş, and Leonard 2018); how Lean leaders can develop a high-exchange relationship with their teams (Seidel et al, 2019); the impact of implementing continuous improvement upon stress within a Lean production framework (Stimec and Grima 2019); the level of work engagement and exhaustion at different stages of Lean implementation (Beraldin, Danese, and Romano 2019).</td>
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<td>Leanness</td>
<td>Examine the factors that determine the functional form of the relationship between inventory Leanness and firm performance (Eroglu and Hofer 2011); the link between operational Leanness and credit ratings reflecting the actual financial risk rather than the perceived one (Bendig, Strese, and Brettel 2017); monetary equivalent of achieving soft savings through increased inventory Leanness (Tasdemira and Hiziroglu 2019); how the context of investigation and the company's dimension (i.e. the technical dimension, the rhetorical dimension and the organisational dimension), involve the operationalization of Leanness influence on company performance (Shashi et al. 2019).</td>
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<td>Lean implementation assessment and measurement</td>
<td>Develop a measurement instrument of the degree of Lean attained by companies (Abreu-Ledon et al. 2018), assess the degree of implementation of Lean strategic actions across firms (Hallam, Valerdi, and Contreras 2018); determine the extent to which each Lean practice is implemented (Galeazzo 2019); explore mechanisms to assist managers in identifying floor (inertial) and ceiling (saturation) points in the adoption of Lean practices (Negrao et al. 2019).</td>
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<td>Lean effects</td>
<td>Study the effect of combining different types of Lean practice bundles on several performance measures (Abreu-Ledon et al. 2018); Lean bundles for explaining successful financial performance (Galeazzo and Furlan 2018); whether different Lean practices increase operational performance (Knol et al. 2018); the impact of investments in Lean practices on financial and market-related performance (Onofrei et al. 2019).</td>
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<td>Lean implementation issues and inter-relationships among Lean elements</td>
<td>Study how exactly Lean-team information sharing takes place and how it boosts precisely Lean-team performance (Dun and Wilderom 2016); how the configurations of Lean bundles change over time (Galeazzo and Furlan 2018); which improvement routines are critical for different stages of the implementation of Lean practices (Knol et al. 2018); the interactions between and within the Lean Manufacturing Practices from an environmental and operational perspective (Bai, Satir, and Sarkis 2019).</td>
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<td>Lean implementation guidelines, framework</td>
<td>Develop an appropriate mix of Lean for-sustainability practices focusing on the design stage, the responsible selection of resources and and waste management of supplied inputs (Leon and Calvo-Amadio 2017); determine the feasibility, reliability, accuracy, and validity of the model consisting of strategic goal (decide which product to delete for a leaner and more sustainable supply chain), group decision making (benefits, opportunities, costs, risks), product deletion decision characteristics, internal operational characteristics, external environmental characteristics and product deletion decision alternatives, through an actual application and feedback (Zhu, Shah, and Sarkis 2018); validate the framework of Lean KPIs which are categorized as qualitative or quantitative, strategic or operational, social or technical, financial or non-financial, leading or lagging, static or dynamic (Sangwa and Sangwan 2018b); consider more attributes or categories (than Operational LMPs, Environmental LMPs, Ease of implementing LMPs), to justify the implementation of LM Practices, such as social sustainability dimensions (Bai, Satir, and Sarkis 2019).</td>
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<td>and methodology</td>
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<td>Lean concept/definition</td>
<td>Expand the Lean construct to include all Lean bundles or elements other than JIT and process set-up time reduction (Chavez et al. 2013; 2015); explore whether Lean has the necessary edge concerning definition (Arlbjorn and Freytag 2013); define the theoretical and rhetorical foundation of Lean (Langstrand and Drotz 2016); study the definitions between Lean and sustainability (Leon and Calvo-Amadio 2017).</td>
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<td>Lean motivation</td>
<td>Determine the motivational potential of the Lean system (Taylor, Taylor, and McSweeney 2013).</td>
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<td>Supply Chain</td>
<td>Study how the firms in a supply chain proceed with Lean implementation, sequential or parallel (Narayananurthy and Gurumurthy 2016a), the contextual influence (e.g. buyer–supplier relationship) of the hypothesis describing the relationship between the implementation of Lean shopfloor practices and Lean supply chain management, and their effect on quality and inventory turnover (Marodin et al. 2017); the impact of procurement system optimization on suppliers (Tasdemira and Hiziroglu 2019); the performance implications of Lean in supply chains and the role of learning orientation and relational resources (Iyer, Srivastava, and Srinivasan 2019).</td>
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<td>Lean integration</td>
<td>Study the effects of decision-making on the integration process of IT in Lean-based manufacturing systems (Pinho and Mendes 2017); the performance implications of an Industry 4.0 and LM integration (Buer, Strandhagen, and Chan 2018); the developent of green-JIT methods and tools (Dieste et al. 2019); the moderating role of Industry 4.0 technologies on the relationship between Lean production and operational performance improvement (Tortorella, Giglio, and Dun 2019).</td>
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<td>with other management approaches/ theories</td>
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<td><strong>Countries</strong></td>
<td>Study how the implementation of each Lean practice varies in different countries, through multiple-case-based studies (Bortolotti et al. 2015); the effectiveness and applicability of the Lean environmental benchmarking method (divided into three stages: preparation, evaluation and analysis of results, which are subsequently supported by three different areas i.e. strategic planning, technical planning and logistics planning) in different countries (Tomelero et al. 2017); the relationship between LP and business and market performance in countries such as Japan, Korea and Latin America (Abreu-Ledon et al. 2018); the moderating role of Industry 4.0 technologies on the relationship between Lean production and operational performance improvement in different countries, regardless of the socioeconomic context (Tortorella, Giglio, and Dun 2019).</td>
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<td>Sectors, manufacturing sub-sectors and organization units</td>
<td>Study the mechanisms of Lean transfer that are more important for medium and large multinational corporations (Boscari, Danese, and Romano 2016); the framework consisting of strategies and portfolio, project management, needs and requirements, concept system, detailed project, testing and validation, manufacturing product launch, monitoring and discontinuity in agroindustries (Lermen et al. 2018); the influence of factors such as location and financial conditions on Lean readiness to further develop the understanding of this phenomenon in the pharmaceutical manufacturing sector (Garza-Reyes et al. 2018b); Lean production and operational performance through expanding the sample to production sectors other than the automotive (Marodin et al. 2019).</td>
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<td>Factors affecting Lean</td>
<td>Determine the impact of dimensions, namely degree of codification, degree of autonomy, prevalent type of ambidexterity on Lean implementation (Secchi and Camuffo 2016); the impact of shopfloor culture and subculture on Lean production practices (Losonci et al. 2017); the role played by other sources of complexity (other than number of elements, interactions, diversity, unexpected variability and resilience) and the detailed dynamics in Lean practices and principles (Soliman, Saurin, and Anzanello 2018); the effect of contextual variables (e.g. national culture, Lean maturity and job complexity) on soft Lean practices, job demands and well-being (Beraldin, Danese, and Romano 2019).</td>
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<td>Research methodologies</td>
<td>Study Lean through real operational performance data (Marodin et al. 2018), data from multiple perspectives, such as leaders, those who would qualify as authentic leaders and their followers, in order to compare results so as to verify the convergence or divergence among different respondents (Tortorella et al. 2018a); the inclusion of interviews to capture relevant qualitative information regarding the LM level (Garza-Reyes et al. 2018b); controlled experiments and directed interviews (Hallam, Valerdi, and Contreras 2018); longitudinal studies to collect more objective output measures or involve front-line supervisors (Tortorella, Giglio, and Dun 2019).</td>
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<td>Research sample size</td>
<td>Research Lean using more plant individuals (Nawanir, Lim, and Othman 2016), large samples of manufacturing companies (Knol et al. 2018); larger number of companies or leaders (Toledo et al. 2019; Rajagopalan and Solaimani 2019); a large sample of employees (Beraldin, Danese, and Romano 2019).</td>
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