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Lean Management, Supply Chain Management and Sustainability: A Literature Review☆

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ABSTRACT

The objective of this paper is to evaluate the state-of-the-art of research into the links between Lean Management, Supply Chain Management and Sustainability with a view to: 1) identifying the topic set studied and contributing a criterion for classifying the literature, 2) discussing the empirical evidence and orienting future research. For this a literature review has been carried out that extends from an internal focus to an entire supply chain focus, and considering, at the same time, the three key dimensions of sustainability. The evaluation of this literature has enabled two main topics of research to be identified: a) Lean Management and Sustainability, and b) Lean Supply Chain Management and Sustainability; as well as a number of more specific lines of research that can be assigned to each of these two research topics. Finally, the paper goes on to discuss the contradictions and inconsistencies found in the literature and proposes new opportunities and challenges that should be addressed by future research.

1. Introduction

Companies in a variety of economic sectors have adopted Lean Management (LM) in recent decades and in many cases this has enabled them to improve their results and their competitiveness (Moyano-Fuentes and Sacristán-Díaz, 2012). However, although many companies have successfully implemented LM, others have not achieved the results that they expected. One thing that these companies had in common was an inability to sustain their results over the medium- and long-term (Lucey et al., 2005). This has created an interest among researchers to examine why they are unable to sustain the results that have come from LM.

At the same time, the changes in the laws and regulations governing the environment, together with growing pressure and demands from stakeholders have resulted in companies developing greater environmental responsibility in recent years (Gordon, 2001). As an integrated management system, LM is not unaffected by these issues and there is a growing interest in the literature in linking LM to environmental sustainability.

In addition, these days it is not enough for many companies that have adopted LM to improve their results but they also want to be seen to be managing their businesses responsibly and to be aware of the impact that their activities are having on society, and they are therefore raising their corporate social responsibility (Taubitz, 2010).

And it is not only intra-organisational aspects that need to be focused upon for further strides to be made in the level of LM implementation; it is also vital for Lean principles and practices to be spread throughout the whole supply chain to derive the potential benefits of LM (Womack and Jones, 1996; Hines et al., 2004). In this respect, one of the main challenges that companies that embark upon Lean initiatives are faced with is increased integration with their key suppliers and customers (Pérez et al., 2010). This is why an analysis of LM should be addressed from both a company focus and a supply chain focus (Hines et al., 2004; Shah and Ward, 2007).

Meanwhile, a number of authors also underscore the fact that LM's 'new frontier' is its link to sustainability (Fliedner and Majeske, 2010) as a result of which it would be interesting to determine the results to date of the impact of LM on the three aspects included in the sphere of sustainability (environmental, economic and social).

For all these reasons we carry out a comprehensive literature review in this study with a view to identifying the interrelationships found to date between LM, Supply Chain Management and the three

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key dimensions of sustainability. Fig. 1 shows the scope of this study's analysis: the shaded areas where the circles intersect, to be precise. Figs. 2–5.

Specifically, this study presents a qualitative analysis of research done to date on these interrelationships with two basic objectives: 1) to identify the topic set studied and contribute a criterion for classifying the literature that will be useful for researchers wishing to begin work in this field, and 2) to discuss the available empirical evidence, detecting contradictions and inconsistencies in the literature and any gaps that enable us to point out any opportunities that exist for future research.

The study has been divided into four parts with this first part devoted to the introduction. The second part provides details of the methodology followed to accomplish the research objectives. The third section is devoted to setting out the findings in terms of classifying the literature and developing the content of the topics and lines of research identified. Finally, the results are discussed with reference to the contradictions, inconsistencies and gaps found in the literature. Conclusions are also provided together with the challenges that future research will have to address and the implications of the findings for management.

2. Methodology

An in-depth evaluation has been conducted of the links in the literature among Lean Management, Supply Chain Management and Sustainability to achieve the objectives that have been set. A literature review has proved to be a crucial step in structuring a field of research (Easterby-Smith et al., 2002) and one that enables a firm basis to be created for making advances in knowledge, facilitating the development of theory, fully resolving areas of research and discovering areas that require further detailed research to be done (Webster and Watson, 2002).

Methodology of this qualitative type has already been used successfully in other similar studies on topics closely linked to the present study, including Lean Production (Moyano-Fuentes and Sacristán-Díaz, 2012), Supply Chain Management (Gunasekaran and Ngai, 2005), Green Supply Chain Management (Srivastava, 2007), and Sustainability (Lorenz and Lützkendorf, 2011).

The literature review process was carried out sequentially following these steps: select, know, comprehend, apply, analyse, synthesise, and evaluate the literature (Levy and Ellis, 2006). Following this process guarantees a structured and effective literature review.

The bibliography that was revised includes peer reviewed journal articles and paradigmatic books with managerial impact on the subject. Dissertations, text-books, unpublished working papers and conference papers were excluded. Literature was taken from journals in the areas of production management, operations management and operations research. Articles were identified in the main bibliographic databases for the period analysed, 1990–January 2013 (see Table 1). The starting point is the year that the reference work that marked the beginning of research on Lean Management, entitled "The machine that changed the world" (Womack et al., 1990), was published. However, we included some significant works published before 1990 since these have been highly cited in other papers as precursors of the linkages between Lean and sustainability.

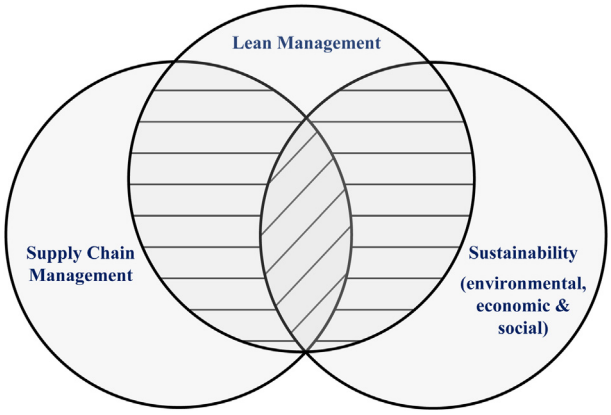

Fig. 1. Objective of the literature review.

Table 1
Summary of methodology used.

Unit of analysis	Relevant books and articles published on the linkages among Lean Management, Sustainability, and Supply Chain Management where these are the main substance of the works and which are frequently cited in the literature. Text-books, unpublished working papers, conference presentations and communications were excluded.		
Type of analysis	Qualitative		
Period of analysis	1990–January 2013		
Search engines	ABI Inform Global (Proquest Direct), Business Source Premier (EbscoHost), ScienceDirect (Elsevier), Wiley Online Library (Wiley), Emerald Insight, Anbar International Management Database, Scopus, Springer Link and ISI Web of Knowledge		
Keywords used in searches	Lean Management	Supply Chain Management	Sustainability
	Lean, Lean Management, Lean Production, Lean Manufacturing, Toyota Production System (TPS), Lean Supply Chain, Lean Supply Chain Management, Lean Supply, Lean Distribution, Lean Supplier, Lean Dealer	Supply, Supply Chain, Value Chain, Supply Chain Integration (SCI), Supplier Integration, Customer Integration, Buyer-Supplier Relationships, Information Technology, Information Systems, Information and Communication Technologies	Green, Green Supply Chain, Green Supply Chain Management, Waste Management, Eco-Efficiency, Reverse Logistics, Environment, Environmental Impacts, Emissions, Energy Efficiency, Ecology Sustainability, Sustainable, Performance, Economic Sustainability, Operating Performance, Financial Performance, Key Performance Indicators (KPIs), Social Aspects, Work Organisation, Worker, Ergonomics, Stress, Corporate Social Responsibility, Corporate Citizenship, Social Performance, Sustainable Responsible Business
Main journals in Operations Management	Journal of Operations Management (JOM), Manufacturing and Service Operations Management (MSOM), European Journal of Operational Research (EJOR), International Journal of Production Economics (IJPE), Production and Operations Management (POM), International Journal of Operations and Production Management (IJOPM), International Journal of Production Research (IJPR)		
Total number of articles evaluated	58		

Table 2
Break-down of papers by area of application and research topic.

Area of application	Total LM & LSCM – Sustainability		LM-Sustainability		LSCM-Sustainability	
	Number of papers	Percentage	Number of papers	Percentage	Number of papers	Percentage
Automotive	13	22.41%	11	20.75%	3	21.43%
Theoretical	28	48.28%	27	50.94%	8	57.14%
Multisectoral	10	17.24%	10	18.87%	1	7.14%
Others	7	12.07%	5	9.43%	2	14.29%
Total	58	100%	53	100%	14	100%

NB. Some papers have been classified under more than one research topic.

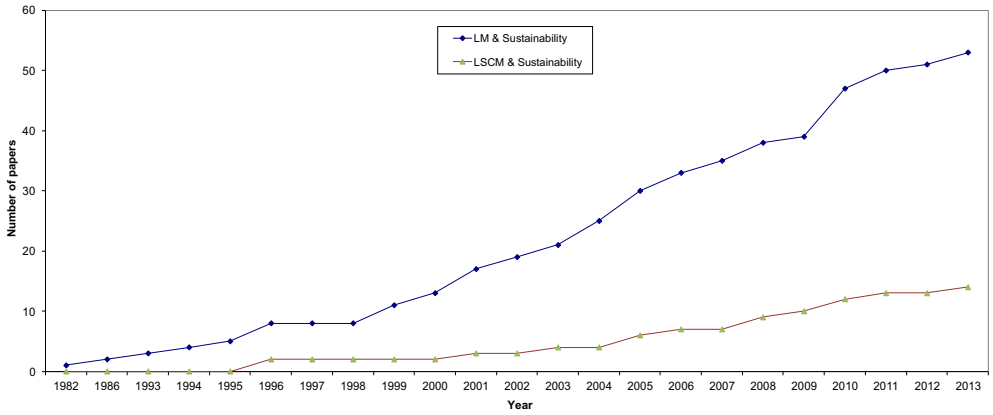

Fig. 2. Cumulative frequency of the number of articles published by research topic.

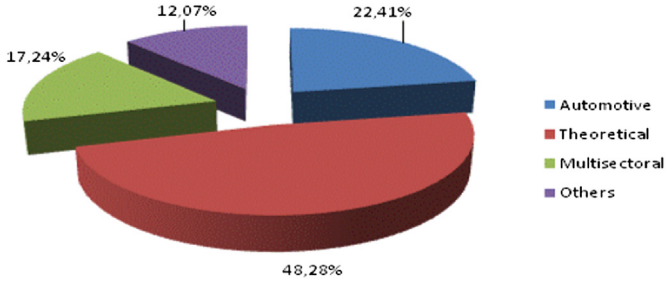

Fig. 3. Distribution of papers by area of application (LM & LSCM – Sustainability).

The keywords and terms used in searches of the various databases are those that are frequently used in the literature to describe and define the area of study of Lean Management, Supply Chain Management and Sustainability. Brainstorming by the researchers was used to select the keywords and, subsequently, the 'snow-ball effect' was used to add keywords to the searches as they were found in the literature. The resulting keywords were used in combination using logical operators in searches by title, keyword, abstract and full article text.

In addition, we wanted to ensure that all articles related to LM that appeared in seven essential journals for the Operations Management area were checked, and all electronic editions of JOM,

Table 3
Literature classification.

Topics/lines of research		Main articles
Lean Management and Sustainability	*Environmental Sustainability*	Maxwell et al. (1993); Cusumano (1994); Florida (1996); Pojasek (1999a, 1999b); Gordon (2001); King and Lenox (2001); Rothenberg et al. (2001); Soltero and Waldrip (2002); Simons and Mason (2003); Larson and Greenwood (2004); Simpson and Power (2005); Corbett and Klassen (2006); Sawhney et al. (2007); Mason et al. (2008); Moreira et al. (2010); Taubitz (2010); Carvalho et al. (2011); Vinodh et al. (2011); Yang et al. (2011); Aguado et al. (2013); Chiappetta-Jabbour et al. (2013); Hajmohammad et al. (2013)
	Economic Sustainability	Lewis (2000); Bateman (2001); Bateman and David (2002); Maskell and Baggaley (2003); Hines et al. (2004); Lucey et al. (2004); Bateman (2005); Comm and Mathaisel (2005); Lucey et al. (2005); Jørgensen et al. (2007); Bhasin (2008); Hines et al. (2008); Fullerton and Wempe (2009); Ho (2010); Sawhney et al. (2010); Turesky and Connell (2010)
	Social Sustainability	Kamata (1982); Schonberger (1986); Forrester (1995); Niepce and Molleman (1996); Pil and MacDuffie (1996); Green (1999); Biazzo and Panizzolo (2000); Suzuki (2004); de Treville et al. (2005); Conti et al. (2006); de Treville and Antonakis (2006); Fliedner and Majeske (2010); Taubitz (2010); Sawhney et al. (2010)
Lean Supply Chain Management and Sustainability	*Environmental Sustainability*	Florida (1996); Simons and Mason (2003); Simpson and Power (2005); Corbett and Klassen (2006); Mason et al. (2008); Mollenkopf et al. (2010); Carvalho et al. (2011); Dües et al. (2013)
	Economic Sustainability	Hines (1996); Arkader (2001); Smith and Tranfield (2005); Comm and Mathaisel (2008); Wee and Wu (2009); Fliedner and Majeske (2010)

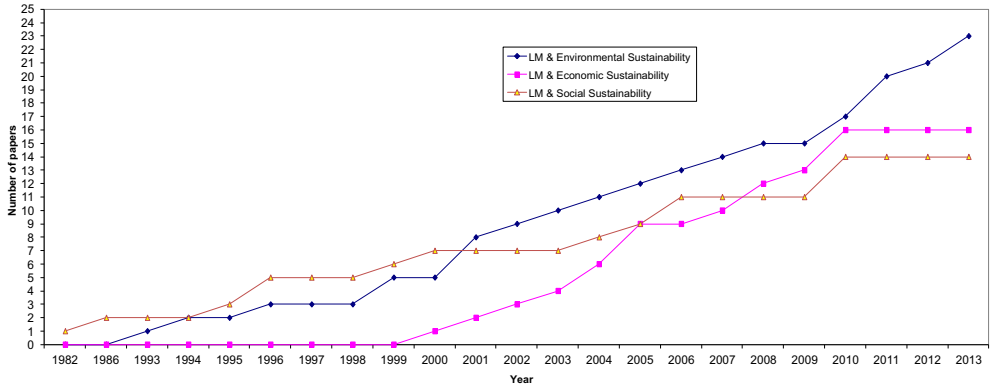

Fig. 4. Cumulative frequency of published articles for the various lines of research on LM and sustainability.

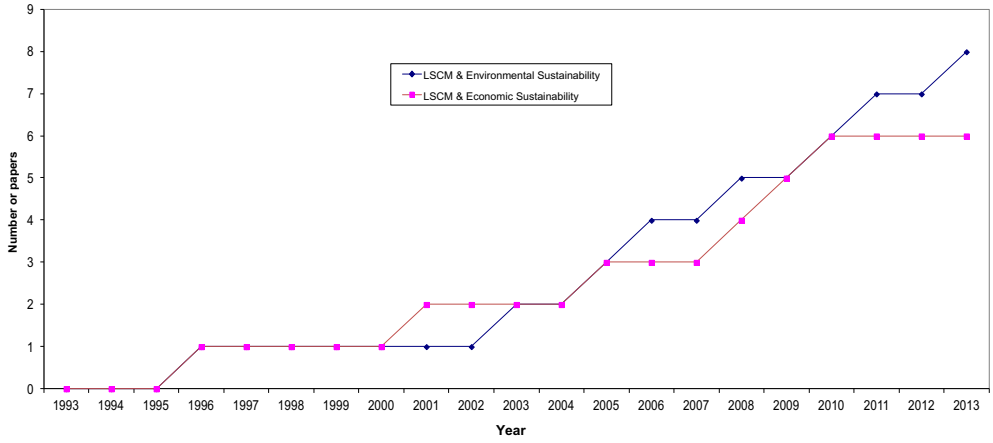

Fig. 5. Cumulative frequency of published articles for the various lines of research on LSCM and sustainability.

MSOM, EJOR, IJPE, POM, IJOPM and IJPR were systematically searched (see Table 1).

The database searches yielded hundreds of articles. Each of the articles was examined to ensure that its content was relevant from the perspective of the aims of our research. Two researchers jointly carried out the examination and selection of the articles on the basis of the criteria that these would only be chosen in which the main contribution revolved around the interrelationships among Lean Management, Supply Chain Management and Sustainability. The result of this process was that 58 articles were eventually selected for in-depth evaluation.

A database was subsequently created to codify and classify the studies and articles with the aim of grouping them according to topic and line of research using the following procedure: 1) analysis of the paper's research question identifying the key aspects related to Lean Management, Supply Chain Management and Sustainability, 2) grouping of key aspects of a similar nature and/or related in lines of research, and 3) grouping of lines of research in research topics on the basis of the interrelationships found among Lean Management, Supply Chain Management and Sustainability.

3. Results

The above-described procedure enabled us to come up with two major research topics linked to the interrelationships among Lean Management, Supply Chain Management and Sustainability. These topics were identified on the basis of the level of analysis used. We first identified a focus on the internal level and then a second broader-based focus on the supply chain. To be more specific, the two research topics identified are: 1) Lean Management and Sustainability, and 2) Lean Supply Chain Management (LSCM) and Sustainability.

Using a chronological perspective we observed how each of these research topics evolved over time and prepared the following graph to show the cumulative frequency of the number of articles published annually during the period under analysis. [Fig. 2]

It can be deduced that the LM and sustainability topic has received and continues to receive greater attention from researchers. Despite the fact that it arose prior to the LSCM and sustainability topic, it has continued to be the subject of an increasing number of contributions over time in the literature. This has meant that the gap in the interest that the two topics attract has widened since 1998. With regard to the present time, it can be seen that there has been a significant growth in the interest shown in the LM and sustainability topic since 2009 and that this is on the rise, whereas there has only been more moderate growth in the interest shown in the LSCM and sustainability topic.

Figure 3 groups together research conducted on the two topics by area of application.

A balance can be seen between empirical and theoretical research. With regard to empirical research, the greater number of studies carried out in the automotive sector should be noted, amounting to around half of all empirical papers. Meanwhile, 17% of published papers dealt with studies that were conducted simultaneously in several different sectors, such as the chemical, electronics, wood-construction, agri-food, financial sectors, etc. The

majority of the studies conducted in specific sectors were not sufficiently significant to warrant them being addressed individually, although certain sectors that they were conducted in do stand out, such as the aerospace sector, metal-working and services.

The following table breaks down the papers by area of application and research topic. (Table 2)

The highest percentage of theoretical papers can be seen to come under the LSCM and Sustainability topic. This is due to the topic having emerged at a later date and covering a broader concept. In empirical terms, there is a greater percentage of papers that analyse several sectors simultaneously in LM-sustainability as its internal focus enables it to be applied in a wider range of sectors.

Several lines of research were also identified within these two major topics to mine these results further. These were characterised by specialising in more specific links between the key terms analysed. Table 3 sets out the proposed classification with the articles that were evaluated ascribed to each of the defined lines of classification and listed by date of publication. It should be indicated that a few articles have been included under more than one line of research as the research issue might, for example, emphasise the relationship between LM and environmental sustainability while at the same time it might have addressed the link between LM and economic sustainability.

Based on the same criterion as used previously, we have prepared the following graphs to show how the cumulative frequency of published articles in specific lines of research under each topic has evolved over the years.

The line of research about the impact of LM on environmental sustainability is the line that has received the most attention from researchers from 2001 onwards. Moreover, this interest has grown in recent years and is currently the only line in LM and sustainability that is being addressed. The line on the influence that LM has on social sustainability is the line that has been most erratic despite the fact that it marks the beginning of research in LM and sustainability. The line related to the repercussions of LM on economic sustainability was the last one to emerge but since emerging it seems to have been the object of growing attention from researchers up to 2010.

It can be seen in this case that researchers have not placed attention on the impact of LSCM on social sustainability. Regarding the other two lines, similar behaviour can be observed with regard to ups and downs in the two lines, signalling periods of growing attention followed by periods with no publications. It can likewise be seen that the first line of research to appear is that which shows interest in the impact on economic sustainability. This line receives growing attention during the 2007–2010 period but no further publications were found in the area from then on. What can be seen for the line of the impact of LSCM on environmental sustainability is quite different. This line gains importance from 2007 and, as in the previous topic, it is the line that continues to receive contributions at the current time.

Appendix A summarises the key contribution and area of application of each of the articles analysed, which are grouped according to the line and topic of research that they come under.

The content of each of the lines of research is addressed in detail in the following sections with special emphasis on the links found, and the contradictions and inconsistencies detected in the literature.

3.1. Lean Management and Sustainability

The analysis of the literature that covers this research topic taken as a whole enabled three lines of research related to the three key aspects included in the concept of sustainability (environmental or ecological, economic and social) to be identified. In this regard, we define sustainability at the business level as meeting the needs of a firm's direct and indirect stakeholders, without compromising its ability to meet the needs of future stakeholders also. According to this definition, three key dimensions or elements of sustainability can be identified: integrating economic, environmental and social aspects in a "triple bottom line" (Dyllikc and Hockerts, 2002).

3.1.1. Lean Management and environmental sustainability

The studies framed within this area all agree that the concepts of Lean and Green or Environmental are complementary and are governed by the following underlying principles:

a) Principle of Waste Reduction. A fundamental principle of LM is to increase added value for the customer by reducing and/or eliminating any activity that does not add value along the product value flow. Similarly, waste reduction and/or elimination is a key issue for environmental sustainability through the reduction or prevention of environmental pollution and the reduction of waste at its point of origin. As such, LM's goal of zero wastage and, consequently, the efficient use of resources leads to the prevention and reduction of environmental pollution (Florida, 1996; King and Lenox, 2001).
b) Process-centred focus. One of the keystones of LM is achieving quality throughout all the steps of the process and so the logic is similar to that of the focus of waste reduction at the point of origin. The Lean focus stresses that solving the problem is not enough and it has to be prevented from occurring again in the future. The same is true of the environmental approach, which stresses the prevention of environmental impacts instead of using solutions at the end of the process, when the consequences are irreversible (King and Lenox, 2001; Sawhney et al., 2007).
c) High levels of people involvement and participation. Another crucial LM keystone is the involvement of people in this management system. This involvement is also vital in the environmental focus for implementing environmental practices and tools/techniques. The advanced human resource management practices inherent in LM (versatile workers, worker involvement in work standardisation, teamwork and the existence of improvement groups) and a continuous-improvement culture in the organisation can facilitate the adoption of environmental management principles and practices (Rothenberg et al., 2001; Soltero and Waldrip, 2002).

On the one hand, empirical evidence shows that Lean companies create opportunities for green manufacturing principles to be adopted, and that they proactively adopt environmental management policies to improve environmental performance, which is one of the key success factors in green transformations (Maxwell et al., 1993; Rothenberg et al., 2001; Chiappetta-Jabbour et al., 2013).

On the other hand, Lean principles and practices have been found to be inherently capable of facilitating the achievement of environmental goals and improvements in environmental results (Gordon, 2001; King and Lenox, 2001; Vinodh et al., 2011). In this respect, researchers have addressed the relationship between the level of LM implementation and environmental performance. Despite the fact that some authors have demonstrated the direct positive effect that implementing a range of LM practices and tools has on environmental results (Moreira et al., 2010; Vinodh et al., 2011), the findings are still not conclusive, as both positive (Florida, 1996; King and Lenox, 2001) and negative (Rothenberg et al., 2001) relationships have been found to exist.

Table 4
Critical Factors for achieving economic sustainability that come from Lean Management.

Articles	Critical factors
Hines et al. (2004); Bhasin (2008); Hines et al. (2008)	It is not enough to focus solely on the implementation of some LM practices and tools/techniques at the plant/factory floor level, but it is necessary to attend to aspects such as cultural change and Lean organisational thinking.
Lewis (2000); Shah and Ward (2007)	Implementing the LM practice set as a holistic/integrated system is crucial and this should be done throughout the whole of the organisation, including both suppliers and customers. Moreover, the company should have the ability to appropriate and maintain the generated value that results from the improvements that it has created.
Hines et al. (2008)	It is necessary to address jointly the strategy and its deployment, the management's leadership, the behaviour and commitment of all company members, process management, and LM technologies, tools and techniques.
Bateman (2001)	Lessons should be taken from past failures and worker commitment should be addressed (through an ongoing process), participation and worker commitment should be strengthened, and the way that implementation is progressing should be monitored appropriately.
Bateman (2005)	The contribution and commitment of everyone in the organisation should be guaranteed, processes implemented to sustain the level achieved and there should be a continuous focus on the improvements introduced, the integration of work cells and the organisation's strategy, and focus and support on an organisational level.
Lucey et al. (2005)	There is a need for a clear vision and for management leadership, an effective communication strategy, the creation and communication of a sense of urgency in changes, frequent consultations with interest groups/stakeholders, structured project management methodology, appropriate monitoring and evaluation of the results, the change should be fully mobilised, the whole of the organisation involved, a specialist team and appropriate resources, suitable human resource policies and practices.
Comm and Mathaisel (2005)	A proactive attitude to deal with the change to Lean, leadership and commitment of top management, change in organisational culture, focus on the role of people, training, communication, a suitable indicator system, ongoing control and monitoring.
Turesky and Connell (2010)	*Adoption stage*: support from top management and communication, continuous communication on all organisational levels, training and development. *Initial stage*: selection of initial project, commitment of people, desire to improve service, management of resistance. *Implementation stage*: suitable selection of initial project team, completion of project, communication of results. *Sustainability of results stage*: responsibility and control over improvements achieved, sense of ownership of improvements, continuous monitoring and control.

The studies that find a positive relationship coincide in pointing out that LM continuously improves resource efficiency[2] (Florida, 1996; Rothenberg et al., 2001) which results in reductions in the use of materials and energy consumption and, consequently, leads to a reduction in environmental pollution (King and Lenox, 2001; Larson and Greenwood, 2004). It has also been found that companies where LM is implemented to a higher degree achieve a reduction in environmental pollution through prevention rather than having to deal with waste once it has been generated (Florida, 1996; King and Lenox, 2001). LM can thus bring down the marginal cost of reducing pollution either by lowering the cost of implementing environmental improvements or by providing information on the value of reducing pollution (King and Lenox, 2001). LM can similarly contribute to reducing the dispersion of toxic substances through the use of fewer raw products (Moreira et al., 2010).

The studies that find a adverse relationship show a negative link between LM and the reduction of Volatile Organic Compounds (VOCs) (Rothenberg et al., 2001).

Despite these non-conclusive results, a number of studies agree that although LM might come into conflict with environmental performance in some areas, especially where pollution control technologies are required, it does nonetheless create significant opportunities for environmental improvement (Rothenberg et al., 2001; Larson and Greenwood, 2004; Sawhney et al., 2007). In this regard, some studies (Yang et al., 2011; Hajmohammad et al., 2013) have recently found that the relationship between LM and environmental performance is mediated by environmental practices. In other words, LM facilitates the adoption and implementation of environmental practices but resources have to be assigned to green practices for all the potential for the improved environmental performance that results from LM to be achieved.

In fact, many Lean companies have been found to have achieved improved environmental results as a secondary effect despite the absence of any strategic guidance to integrate the principles of LM and the principles of "Green" Manufacturing (Sawhney et al., 2007; Moreira et al., 2010; Taubitz, 2010; Vinodh et al., 2011; Yang et al., 2011). Some recent studies (Vinodh et al., 2011; Aguado et al., 2013) in the area underscore the importance of integrating LM initiatives and "Green" Manufacturing and propose methodologies for joint implementation. In the same respect, some authors adapt a series of Lean practices and tools for their incorporation into environmental principles, such as value stream mapping, 5S, kaizen events and error-proof methods; this emphasises the need for LM practices to be adopted with an environmental focus (Pojasek, 1999a, 1999b; Soltero and Waldrip, 2002; Simons and Mason, 2003; Mason et al., 2008).

3.1.2. *Lean Management and economic sustainability*

One aspect that has attracted growing interest from researchers is the identification of the factors that explain the sustained operational and financial results that result from LM implementation in the medium- and long-term (Bateman and David, 2002; Lucey et al., 2005; Moyano-Fuentes and Sacristán-Díaz, 2012). This section analyses the studies that focus on this phenomenon and these are presented in the following table grouped by the factors that are critical for achieving the sustainability of results. (Table 4)

It can be deduced from this Table that there is widespread agreement about the decisive role that human resources play and of the cultural change that implementing Lean requires for sustainable results to be achieved (Bateman and David, 2002; Hines et al., 2004; Lucey et al., 2004; Bateman, 2005; Hines et al., 2008). Stress is also placed on the importance of the direct involvement of the personnel and the leadership and commitment of the management for Lean to achieve this aim (Hines et al., 2008).

The authors also coincide in the complexity of achieving sustainable results through Lean due to the need for the various practices that it is made up of to be implemented simultaneously. This is why Lean implementations are hard to imitate and, therefore, to extrapolate from one company to another in their entirety (Lewis, 2000; Shah and Ward, 2007).

For the results that are achieved by Lean to be sustained over time the authors stress the importance that should be given to the conditions of the point-of-departure and the environment/context

[2] A number of case studies conducted by the United States Environmental Protection Agency (EPA) have found a wide range of environmental benefits that come from successfully implementing LM principles and practices (EPA, 2000, 2003; 2007).

and that a strategic approach should be used when adopting LM (Hines et al., 2008; Sawhney et al., 2010). Other authors state that the use of traditional financial systems and the consequent lack of monitoring and evaluating Lean results is what explains the fact that companies do not obtain stable results from LM (Maskell and Baggaley, 2003; Fullerton and Wempe, 2009). To correct this weakness authors have developed methodologies for implementation and the evaluation of results with a view to ensuring the sustainability of the latter (Jørgensen et al., 2007; Ho, 2010; Sawhney et al., 2010).

3.1.3. Lean Management and social sustainability

The research has not only brought to light the importance that delivering greater value, has for Lean companies, but also contributing to social equity (Moreira et al., 2010; Taubitz, 2010). In fact, it is not enough for Lean companies to achieve improved results; they must also be seen to be managing their business responsibly, and to be aware of the impact that their activities are having on society (Mason et al., 2008). In this regard, the aspect that has received the greatest attention from authors with respect to the link between LM and social sustainability is the impact that this management system has on people and on issues related to health and safety in the work place.

The evaluation of the literature on the impact that LM has on people does not provide conclusive results. On the one hand, one of the basic principles of LM is the role of people, and it has been recognised that the way that people are treated, explicit efforts to incorporate their suggestions, respect for people and their acknowledgement are the 'glue' that make the other aspects of LM stick together (Womack and Jones, 1996; de Treville and Antonakis, 2006). In fact, factors such as motivation, communication, problem-solving and teamwork, and not forgetting cultural change, are vital for the success of LM (Hines et al., 2008). In fact, the workers in Lean companies assume responsibilities that go beyond production tasks and the way that they are compensated is based more on their abilities than on the number of operations that they carry out. This is why, generally-speaking, Lean has a positive effect on workers' attitudes (Womack and Jones, 1996).

On the other hand, there are authors who stress that LM adoption is complex due to the nature of high participation in work organisation practices (Pil and MacDuffie, 1996). So, the adoption of LM implies integration in the use of operations management (OM) and human resource management (HRM) practices. The early integration of OM and HRM practices is indeed associated with productivity (de Menezes et al., 2010). There is, however, no consensus with regard to how LM might affect human resources. While some authors state that there is a reduction in stress (Conti et al., 2006), more varied work (Schonberger, 1986), increased responsible autonomy (de Treville et al., 2005) and a rise in intrinsic motivation (Niepce and Molleman, 1996; de Treville and Antonakis, 2006), other authors point to the fact that the work is more intense, there is more stress and a loss of autonomy and freedom (Forrester, 1995; Green, 1999). In this respect, one of the most common criticisms of LM is that it is extremely exploitative and puts excessive pressure on people (Hines et al., 2004). Nonetheless, teamwork, the support of top management for the tasks to be carried out and worker participation in improvements help reduce the stress on workers, as a result of which worker stress should be linked to the extent that LM is implemented (Conti et al., 2006). Sawhney et al. (2010) state that as LM implementation advances, so the work becomes harder, and more intense, monotonous and standardised. The stress factor is frequently so high that it affects both workers' morale and the trustworthiness of the system. This is, in fact, not only a western phenomenon, even in Japan the workforce suffered a loss of autonomy and increased stress due to LM (Kamata, 1982; Green, 1999). In this respect, some authors state that LM might result in a loss of stable jobs and a lower quality of life for workers, and that this would have a negative effect on their commitment (Biazzo and Panizzolo, 2000; Suzuki, 2004).

Table 5
Basic principles and practices of the Lean Supply Chain compared to traditional supply chains.

Basic principles and practices	Traditional supply chain	Lean Supply Chain
Relationship patterns	Sporadic transactions with a distant and contrary attitude	Collaborative relationships based on mutual trust and commitment
Time horizon	Short term	Long term
Supply chain set up	Large supplier base and large-scale vertical integration	Small supplier base, low vertical integration, and system and sub-assembly supply
Number of suppliers by component	Multiple supply sources	Single or dual supply. Supply sources in closer proximity
Supplier choice and evaluation	Mainly price-based criteria	Multifaceted criteria focussing on supplier capability and added value, and on prior relationship
Technical support	Non-existent focus or with limited scope	Supplier development programmes
Communication and information sharing	Non-existent or infrequent	Frequent with open-door policies
Participation in design and engineering activities	Non-existent or infrequent	Frequent participation from early stage of design and new product development process
Delivery practices	Not very frequent	Very frequent
Attitude towards quality	Less strict post-manufacture inspection	Strict process and evaluation systems
Problem solving	Limited feedback, low levels of shared risk and benefits, independent	Frequent feedback, high levels of shared risk and benefits, working together towards shared solutions

Source: Generated by the authors based on Dyer and Ouchi (1993); Lamming (1993, 1996); Helper and Sako (1995); Hines (1996); MacDuffie and Helper (1997); Sako and Helper (1998); Dyer and Nobeoka (2000); Arkader (2001); Barla (2003); Wu (2003); Simpson and Power (2005); Smith and Tranfield (2005), Cagliano et al. (2006), and Shah and Ward (2007).

As far as the impact of LM on autonomy is concerned, a distinction should be made between the autonomy to choose and responsible autonomy (de Treville et al., 2005). The first of these, which refers to the free choice of procedures and work scheduling, should be low, whereas responsible autonomy, which refers to the responsibility that comes from the decentralisation of authority, power-sharing and participation in decision-making, should be high (de Treville and Antonakis, 2006). These authors find that the design of Lean work can generate intrinsic motivation and increased responsible autonomy but, nevertheless, it is likely that there are substantial differences for different LM configurations.

As far as health and safety in the work environment is concerned, there seems to be a consensus on LM affording the ability to design workstations in accordance with ergonomic standards (Taubitz, 2010; Vinodh et al., 2011), which improves workers' work conditions. However, Vinodh et al. (2011) call for a transition from 5S to 7S in order to include a wider spectrum of issues relating to health, safety and sustainability.

3.2. Lean Supply Chain Management and Sustainability

3.2.1. Lean Supply Chain Management: prior concepts and their links with sustainability

LM principles and practices can be applied right across the supply chain, from the procedure to place the order with suppliers

to product distribution and delivery to the customer, with the aim of optimising all the activities as a whole from the final customer's point-of-view. This is known as Lean Supply Chain Management and is made possible by eliminating wastage, improving quality, reducing costs and increasing flexibility at all stages of the supply chain (Womack et al., 1990; Womack and Jones, 1996).

The following Table provides a comparison between the basic principles of Lean supply chains and traditional supply chains (Table 5).

We define sustainable supply chain management as the management of materials, information and capital flows, and cooperation between companies along the supply chain, while taking into account goals from all three dimensions of sustainable development that derive from customer and stakeholder requirements (Seuring and Müller, 2008).

These Lean Supply Chain Management principles and practices impact on economic sustainability in the following way: a positive impact of the level of internal LM implementation on both customers and suppliers (Simpson and Power, 2005; So and Sun, 2010), improvements in results to be achieved in the chain as a whole (Pérez et al., 2010), business risk reduction through joint investments in R&D and technology, reduced inventories, improved product quality, increased knowledge through collaborative product design or an overall reduction in wastage throughout the supply chain (Hines, 1996; Arkader, 2001).

In the same way, LSCM is crucial for achieving environmental sustainability across the supply chain and, ultimately, all the potential benefits of the Green Supply Chain strategy (Mollenkopf et al., 2010). Thus, LSCM impacts on environmental sustainability in the following way: close and long-term relationships trigger the adoption of environmental management practices (Florida, 1996), some practices and tools, such as Lean supplier development and value stream mapping, could be very useful for adopting environmental management practices (Simpson and Power, 2005; Mason et al., 2008), collaborative design from the very first stages of product development impacts on environmental design to reduce environmental pollution throughout all stages of a product's life cycle (e.g., closed-loop supply chain) (Carvalho et al., 2011).

However, empirical evidence shows that researchers have focused on analysing 'upstream' Lean principles and practices, while little work has been done on analysing how they have been applied 'downstream'. This could be the result of the slow uptake of LM principles 'downstream' in the chain (Womack and Jones, 2005; Reichhart and Holweg, 2007) and could be explained by the principle of production levelling (*heijunka*), as the need for production programmes being stable in long term conflicts with variability in market demand (Naylor et al., 1999; Mason-Jones et al., 2000). There are also successful cases that come from extending Lean principles right to the final customer. Womack et al. (1990) and Kiff (2000) find that automobile manufacturers that have managed to extend LM to the distributors have achieved greater profits during the product's life cycle, greater customer loyalty, benefits from customer knowledge for product development and improved sales forecasts.

On the other hand, Information and Communication Technologies (ICTs) facilitate Lean supply chain development and management by allowing greater integration with customers and suppliers (Bruun and Mefford, 2004; Adamides et al., 2008). Nevertheless, despite being complementary initiatives in concept, it can also be seen that the ICTs and LM can come into conflict, and so companies must plan how their investments are distributed between the two if they are to achieve sustainable competitiveness. The authors agree that before making large-scale investments in ICTs, companies must begin by adopting LM, and subsequently adopt ICTs in order to strengthen and improve the results obtained with LM, and that this might lead to their results being sustained over time (Ward and Zhou, 2006; Mo, 2009).

With respect to external integration, a wide-scale consensus has been found to the effect that ICTs can act as a catalyst for developing and managing Lean supply chain operations not only through the simple exchange of information, but as a mechanism for achieving greater collaboration in some crucial aspects of LM, such as the identification and optimisation of value flows, the alignment of the supply chain strategy and the overall operations strategy, collaborative planning and new product design and development (Homer and Thompson, 2001; Bruun and Mefford, 2004; Ward and Zhou, 2006; Adamides et al., 2008).

However, Ward and Zhou (2006) find that the absence of appropriate ICT infrastructure on the internal level, and low quality input data for external (or inter-organisational) ICT systems are the main reasons why ICT implementations to manage the Lean supply chains have failed. For this reason Hong et al. (2010) stress the need for distinguishing between the types of ICTs used for achieving Lean supply chain goals and find that while ICT for e-commerce and e-procurement have a positive impact on supply chain performance, ERPs do not have a significant impact.

Once we had set out the key aspects of LSCM and the linkages and connections with sustainability, we turned our attention to the literature that covers the research topic linked to Lean Supply Chain Management and Sustainability. This enabled two lines of research to be identified related to two of the key aspects that the concept of sustainability covers: environmental and economic. Research efforts have been directed towards the study of environmental and economic matters, leaving social issues in the background. The main relationships found in the literature in the two fields identified are presented below.

3.2.2. *Lean Supply Chain Management and environmental sustainability*

There is a line of research that analyses the relationship between Lean Supply Chain Management and environmental sustainability. The underlying idea of this line is that environmental pollution can be generated throughout all the stages of a product's life cycle (Zhu et al., 2005) and that an integrated vision is therefore required instead of a focus on achieving islands of environmental improvement (Mason et al., 2008).

The empirical evidence shows that research focussing on the link between Lean Supply Chain Management and environmental sustainability has evolved independently to that which focuses on green supply chain management. Despite this, a growing interest has arisen in addressing the complementarity of said strategies or any possible conflicts between them (Simpson and Power, 2005; Corbett and Klassen, 2006; Mollenkopf et al., 2010).

On the one hand, the Lean supply chain strategy has focused on spreading Lean principles and practices across the supply chain and on reducing wastage in the supply chain, enabling companies to improve quality, delivery times and customer service and to reduce costs (Lamming, 1993; Womack and Jones, 1996). On the other hand, the Green supply chain strategy has focused on close cooperation with suppliers and customers, on the analysis of processes and internal operations and on environmental considerations of product life cycles and on the new product design and development process. This strategy has enabled improvements to be made in both environmental and business results (Zhu et al., 2005; Corbett and Klassen, 2006).

As for synergies between the two strategies, some studies state that they both coincide in the principle of eliminating wastage in all its forms (Lamming, 1996; Mollenkopf et al., 2010). Other studies highlight the fact that Lean supply chains can facilitate the adoption and spread of environmental practices and innovations among

Table 6
Main contributions, future developments and implications for practicioners by Line of Research.

Topic of research	Line of research	Findings and contributions	Future research developments	Implications for practitioners
Lean Management and sustainability	Lean Management and environmental sustainability	- LM is beneficial for adopting environmental principles and improving environmental results. - LM brings about an improvement to environmental results, especially those linked to resource efficiency and preventing environmental pollution (Rothenberg et al., 2001). - The results are still not conclusive and this could be due to the complexity that this relationship entails, as it depends as much on Lean principles and practices/tools/techniques as on the key environmental performance indicators used in the research (Sawhney et al., 2007). - Many of the environmental improvements that come from LM implementation have also been detected to have been achieved indirectly, as no strategic focus was used when integrating lean and environmental principles (Larson and Greenwood, 2004; Moreira et al., 2010). - The adoption of Lean and Environmental focuses should be approached jointly so that any conflicts can be managed and advances made in achieving sustainable results in the two areas, economics and the environment. - The bibliometric analysis shows that this is the line of research that is sustaining this research topic as it is the only one in which advances have been made in research in recent years.	- To research on the impact that LM principles, practices and tools have on environmental performance. - More robust LM measurement constructs and a wider range of environmental performance indicators must be used and different industrial settings investigated to understand the impact of legislation concerning the environment and other contingent factors that might affect the LM-environmental performance relationship. - Qualitative studies should also be carried out in the line of recent results that point to environmental practices having a major mediating effect on the LM-environmental results link (Yang et al., 2011; Hajmohammad et al., 2013) in order to discover whether companies that simultaneously integrate environmental principles and practices into their LM adoption strategy achieve better environmental results. - To develop a model to indicate the sequence that should be followed for the joint adoption and implementation of LM-Green strategies.	- To reach a strategic vision of the impact of LM implementation on environmental sustainability. - To help managers to integrate lean principles and environmental principles.
	Lean Management and economic sustainability	- LM's impact on results is a complex phenomenon that cannot be simplified into only two states, sustainable results and non-sustainable results, but there may be a number of intermediate states (Bateman and David, 2002). - The human factor and cultural change are critical for sustaining the results that come from LM (Bateman, 2005; Lucey et al., 2005). In this respect, the lack of sustainability of the results could be caused by a tight focus on specific practices and tools/techniques with insufficient attention paid to the cultural and organisational change that LM entails, by not conceiving LM as a comprehensive management system or by defects in the monitoring and control of the results of LM. Methods have recently been developed to get round this last problem that include the continuous evaluation of LM results and thus make it easier for them to be sustained over time	- To determine the critical factors that affect the sustainability of the results distinguishing among various phases of the LM implementation process. - Methods and tools also have to be developed in order to achieve an appropriate assessment of LM results and make it easier for management to monitor and evaluate them and then take the right corrective measures that enable LM results to be sustained.	- To understand the factors that allow a sustainable competitive advantage to be gained from the implementation of Lean. - To manage the LM implementation process towards achieving sustainable results over time.

Table 6 (*continued*)

Topic of research	Line of research	Findings and contributions	Future research developments	Implications for practitioners
		(Jørgensen et al., 2007; Ho, 2010; Sawhney et al., 2010).		
	Lean Management and social sustainability	- The research in this field has focused on the impact that LM has on people and on health and safety-related aspects within the company. - The results are not conclusive with respect to the impact on people. On the one hand, positive LM-related aspects, such as increased job variety, improved decision-making, increased responsible autonomy, improved intrinsic motivation, the putting in place of ergonomics standards, better workstations and a reduction in stress have all be found. But on the other hand, the research also shows negative LM-related aspects, such as increased stress, the monotony that comes from standardised work tasks, a loss of autonomy and a low quality of life at work.	- To look in greater depth at how LM affects workers in order to shed some light on the contradictory results regarding the impact on stress, motivation and variation in the job. - To adopt qualitative methodologies such as the "action research" in order to shed light on this relationship.	- To understand how to manage the cultural change associated with LM implementation. - To take advantage of the positive aspects of LM implementation for people.
Lean Supply Chain Management and Sustainability	Lean Supply Chain Management and environmental sustainability	- The research in this field can be seen to be in its beginnings and is addressed by few studies. - There is agreement that synergies exist between the Lean Supply Chain and Green strategies and the research finds that Lean supply chains facilitate the adoption and spread of environmental principles and practices among supply chain members with a consequent improvement in the chain's environmental performance (Lamming, 1996; Simpson and Power, 2005; Corbett and Klassen, 2006; Carvalho et al., 2011). It can therefore be concluded that the adoption of the Lean Supply Chain and Green strategies should be approached jointly as this allows any barriers to simultaneously achieving sustainable economic and environmental results to be overcome (Mollenkopf et al., 2010; Carvalho et al., 2011; Duës et al., 2013). - The bibliometric analysis shows that this line is the only one in which advances are still being made in the influence of LSCM on sustainability topic.	- The impact of Lean Supply principles and practices on environmental performance should be looked at in greater depth. Any correlation between the level of Lean Supply Chain Management and the sustaining of chain results over time should be investigated. - To research into the integration of Lean Supply Chain/Green Management and, especially, into matters relating to the ecological design and extended responsibility for the product, with the adoption of recycling strategies or the maximisation of the use of renewable resources with the idea of achieving what is known as the "Closed-Loop Lean Supply Chain". - To develop empirical studies on different industrial sectors as considering specific factors in industrial processes and specific environmental regulation plays a crucial role in the adoption of the appropriate environmental management practices and environmental results. For this reason we propose the use of Contingent Theory.	- To know how to make the Lean Supply Chain and the Green strategies mutually compatible. - To identify the barriers that must be overcome in order to achieve a Lean and Green Supply Chain.
	Lean Supply Chain Management and economic sustainability	- It has been detected that the few studies that address this relationship use an analysis focus that is restricted to the sustainability of operating results and there are no studies that address the impact that Lean Supply Chain Management has on the sustainability of financial results.	- To research the impact that Lean Supply Chain Management has on the sustainability of financial results as this will enable greater sustainable economic value to be achieved in connection with the initiatives to coordinate the whole of the Lean supply chain (Fliedner and Majeske, 2010). - To discover the critical factors that influence economic sustainability in Lean supply chains, as there are no studies	- To understand the key factors that influence economic sustainability in the Lean Supply Chains in which they play a part. - To help senior management with their decision making related to the monitoring of the results of Lean Supply Chain Management.

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Table 6 (*continued*)

Topic of research	Line of research	Findings and contributions	Future research developments	Implications for practitioners
			that specifically deal with this issue. - To build a system for evaluating and monitoring Lean Supply Chain Management-linked results. - To carry out studies that analyse the impact that a range of Lean Supply Chain practices and tools have on economic sustainability.	

chain members during the product's entire life cycle and thus improve environmental performance across the chain (Florida, 1996; Simpson and Power, 2005; Corbett and Klassen, 2006). Specifically, value stream mapping could be adapted to put ecological thinking into practice throughout the supply chain (Simons and Mason, 2003; Mason et al., 2008).

In fact, Florida (1996) finds that close relationships between Lean supply chain members facilitate the adoption and spread of environmental practices and innovations among members. Specifically, LM can act as a facilitator for achieving greater cooperation in the design and development of new, more environmentally-efficient products, as well as the management of the product at the end of its useful life. Similarly, Lean companies are stated to be incorporating environmental criteria into their supplier selection process and are thus becoming mindful of the fact that the environmental capabilities of their suppliers are becoming more and more important for the Lean supply chain (Simpson and Power, 2005). In this way, if the lean supplier development strategy is conducted with the direct involvement of the customer it has a positive influence on the supplier's environmental management practices and a knock-on effect on improving the supplier's environmental results and, also, those of the customer (Simpson and Power, 2005).

Other positive results that come out of the synergy between the Lean and Green Supply Chain Management strategies are reductions in inventory levels, excess capacity, and transport and production times, and increased levels of integration and frequency of information sharing throughout the supply chain (Carvalho et al., 2011).

With respect to potential conflicts between the Lean – Green supply chain management strategies, several studies state that Just-In-Time (JIT) logistics and, more specifically, the demand for deliveries in small lots and transported more frequently in smaller vehicles leads to greater traffic congestion and more pollution (Katayama and Bennett, 1996; Zhu et al., 2005; Carvalho et al., 2011). However, other authors indicate the opposite effect of JIT logistics on pollution. Cusumano (1994) states that the Lean companies in Japan have partially changed their JIT delivery systems and reduced delivery frequency and/or adapted lot size in order to reduce urban congestion and environmental pollution. Similarly, Maxwell et al. (1993) stress the fact that Lean companies are more likely to use reusable containers for their JIT deliveries for environmental and cost reasons, putting the emphasis on effective and efficient transport.

It can therefore be concluded that identifying potential conflicts between Lean and Green Supply Chain Management strategies and developing solutions to mitigate their negative effects can help the Lean supply chain to be more efficient, to be more responsive and to be more sustainable (Mollenkopf et al., 2010; Carvalho et al., 2011; Duës et al., 2013). In this respect, the recent study by Dües et al. (2013) identifies potential areas in which companies can integrate Green practices in their Lean Supply Chain Management initiatives and the attributes which distinguish the two paradigms, concluding that the Lean Supply Chain has benefits for Green practices and, in turn, the implementation of Green practices has a positive influence on existing Lean Supply Chain practices.

3.2.3. *Lean Supply Chain Management and economic sustainability*

The literature analysis shows that research is beginning to concern itself with the sustainability of the results that come from the implementation of Lean Supply Chain Management. However, it was detected that these studies focus on LM's positive impact on operating results throughout the entire supply chain (Hines, 1996; Womack and Jones, 1996; Smith and Tranfield, 2005) and there are still no studies on the financial results of companies that are part of a Lean Supply Chain.

Other authors stress how important it is to carry on using Lean practices such as value stream mapping in Lean Supply Chains in order to improve results continuously and sustainably (Wee and Wu, 2009). Nevertheless, it is recognised that Lean principles only extend to first-tier manufacturers and suppliers in the supply chain, which makes it difficult to achieve sustainable results throughout the chain. This even happens in the automobile industry, which pioneered the implementation of Lean principles (Arkader, 2001) and yet which displays little implementation downstream in the supply chain (Womack and Jones, 2005; Reichhart and Holweg, 2007). This limited focus reduces the potential benefits that a Lean supply chain can achieve (Fliedner and Majeske, 2010) and points to the desirability of adopting a strategic focus in customer–supplier relationships with Lean principles being extended to second and third-tier suppliers in order to obtain the potential overall benefits (Arkader, 2001; Lyons et al., 2004). It is also highlighted that for the results in the Lean supply chain to be sustained logistics and distribution systems need to be improved, ICTs implemented to integrate customers and suppliers, and cooperative relationships with customers and suppliers continuously improved (Comm and Mathaisel, 2008).

4. Discussion and conclusions

The evaluation of the literature on the interrelationships between LM, Supply Chain Management and sustainability has enabled us to provide a classification with groupings around the two major research topics. Then, within these two major topics, lines of research have been identified according to the focus and level of analysis used, ranging from an internal to a supply chain wide focus. This classification and differentiation of research has enabled us to determine the gaps that exist and draw conclusions as to aspects that require further research in the future. The grouping proposed in the literature will be used to address these aspects. In the following table, we summarise findings and contributions and the future developments of the research (Table 6).

It must be stressed that there is a significant gap regarding research into social sustainability in Lean Supply Chain Management. To be precise, key social performance metrics need to be identified, a methodology established for their assessment in the

lean supply chain context and the way to provide opportunities for impoverished communities explored. A fundamental question is how to define the meaning of "lean supply chain social impact". An agreement on what the social impacts of a lean supply chain are would help foster research in this field. There is an opportunity to fill this gap by developing a common sphere of knowledge of the interface between development and sustainable supply chain research fields.

With regard to the limitations of this study, it must be pointed out that the theoretical nature of this paper has not provided conclusive results on the impact of LM and LSCM on sustainability. Considering the findings of this study, an integrated perspective is therefore required for future research focussing on Lean Supply Chain Management, where social issues in particular and LSCM's interrelationships with the three dimensions need to be researched in greater depth.

Appendix A. Detailed analysis of the key contribution and area of application of each of the papers analysed

Topics	Lines of research	Author/s	Area of application	Key contribution
Lean Management and Sustainability	Environmental Sustainability	Maxwell et al. (1993)	Automotive	Positive impact of LM (acts as a driver/facilitator) on the adoption of environmental principles and practices.
		Cusumano (1994)	Theoretical	Impact (negative) of JIT deliveries on some environmental outcomes (higher urban congestion and environmental pollution). However, Lean companies proactively adopt environmental practices in order to mitigate environmental pollution.
		Florida (1996)	Multisectoral	Impact of LM on environmental results. Positive effect, mainly on resource efficiency, prevention and reduction of environmental pollution.
		Pojasek (1999a)	Theoretical	Adaptation of 5S (Lean tool) for its integration into environmental principles and practices.
		Pojasek (1999b)	Theoretical	Adaptation of waste reduction (Lean principle) and poka-yoke (Lean tool) for its integration into environmental principles and practices.
		Gordon (2001)	Multisectoral	Study of synergies between LM and Green initiatives. Transition guide to a joint implementation of LM & Green (examples of "Success Stories").
		King and Lenox (2001)	Multisectoral	Impact of LM on environmental results. Positive effect, mainly on resource efficiency, prevention and reduction of environmental pollution. Positive impact of LM (as an inherent facilitator) on the adoption of environmental principles and practices.
		Rothenberg et al. (2001)	Automotive	Impact of LM on environmental results. Negative effect on some environmental metrics (reduction of VOCs). Positive effect on resource efficiency. Some conflicts between LM & Green. However, LM facilitates the proactive adoption of environmental management principles and practices.
		Soltero and Waldrip (2002)	Theoretical	Study of potential synergies between LM and Green. Lean culture facilitates the adoption of environmental principles and practices. Adaptation of kaizen events (continuous improvement) for its integration into environmental principles and practices.
		Simons and Mason (2003)	Theoretical	Adaptation of VSM for its integration into environmental principles and practices. Internal and external LM focus.
		Larson and Greenwood (2004)	Theoretical	Study of potential synergies between LM and Green. LM inherently facilitates the adoption of environmental principles and practices and, consequently, leads to reductions in environmental pollution. It is crucial to adopt a strategic focus for integrating LM and Green initiatives (great opportunities).
		Simpson and Power (2005)	Automotive	Development of a theoretical model for the integration of internal LM, Lean Supply and environmental practices. Study of synergies and conflicts between LM and Green initiatives.
		Corbett and Klassen (2006)	Theoretical	LM inherently facilitates the improvement of environmental results; however, it is crucial to adopt a strategic focus for integrating LM and Green initiatives (great opportunities). Study of synergies and conflicts between them.
		Sawhney et al. (2007)	Metal-working	Development of a methodology to assess the relationship between LM principles and practices and their impact on environmental results (metrics framework).
		Mason et al. (2008)	Theoretical	Adaptation of VSM for its integration into environmental principles and practices. Greater extension to supply chain management.
		Moreira et al. (2010)	Theoretical	LM inadvertently improves some environmental results. It is crucial to adopt a strategic focus for integrating Lean and Green initiatives (great opportunities).
		Taubitz (2010)	Theoretical	Theoretical guide for integrating LM, Green and Safety issues. Lean culture is a driver to the adoption of Green and

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Topics	Lines of research	Author/s	Area of application	Key contribution
				Safety initiatives.
		Carvalho et al. (2011)	Theoretical	Literature review on potential synergies and conflicts between LM and Green from both an internal and Supply Chain focus.
		Vinodh et al. (2011)	Theoretical	Development of a methodology for the integration of LM and Green initiatives (joint implementation). Transition from 5S to 7S (safety & sustainability).
		Yang et al. (2011)	Multisectoral	Impact of LM on environmental results. This relationship is mediated by the adoption of environmental practices. Thus it is crucial to assign resources to green practices to resolve the conflicts between LM and environmental performance. A prior LM initiative is positively related to the adoption of environmental management practices.
		Chiappetta-Jabbour et al. (2013)	Automotive	LM has greater influence on Environmental Management (EM) practices compared to the influence of some HR practices on EM practices.
		Aguado et al. (2013)	Metal-working	Development of a methodology focussing on synergies between LM and Green. Assessment of the improvements achieved.
		Hajmohammad et al. (2013)	Manufacturing plants	Study of the relationships between LM, Suppliers Management (SM), Environmental Practices and Environmental Performance. The degree of implementation of Environmental Practices mediates the relationship between LM and SM and Environmental Performance. The impact of LM, and to a lesser extent SM, on Environmental Performance is mediated by environmental practices.
	Economic Sustainability	Lewis (2000)	Automotive	It is crucial to achieve and retain the strategic resources (Resource-Based View) generated during the learning curve towards LM. LM results and its sustainability are contingent to the company (market, technology or supply chain structure).
		Bateman (2001)	Theoretical	Identification of facilitator factors for achieving continuous improvement. Mainly focussing on LM process improvement activities. Stresses people's commitment and appropriate monitoring of the results.
		Bateman and David (2002)	Automotive	Development of a model for assessing LM sustainability. Focuses on facilitators and inhibitors both within manufacturing shop-floor cells and across the factory. The sustainability of LM results has many intermediate states.
		Maskell and Baggaley (2003)	Theoretical	Development of a transition guide to transform a traditional accounting system to one that supports and enables LM efforts. Lean Accounting.
		Hines et al. (2004)	Theoretical	Identification of key determinants causing the lack of sustainability of LM results (little attention paid to contingent factors, narrow focus on the production area rather than a strategically-oriented approach, lack of attention to people, and inability to deploy LM principles and practices across the supply chain).
		Lucey et al. (2004)	Pharmaceutical	Development of a long-term LM sustainability framework (Key determinants such as communication and people's commitment).
		Bateman (2005)	Automotive	Identification of facilitator factors (ten) for achieving continuous improvement. Mainly focuses on LM process improvement activities. Stresses people's commitment and strategic issues.
		Comm and Mathaisel (2005)	Service	Identification of facilitator factors (e.g., a proactive attitude to deal with the LM change, leadership and commitment of senior management, change in organisational culture, focus on the role of people, and a suitable indicator system).
		Lucey et al. (2005)	Multisectoral	Identification of key determinants for sustaining LM results. Stresses people and change management issues.
		Jørgensen et al. (2007)	Multisectoral	Development of a capability framework based on two main approaches: technical and organisational. This roadmap shows the company's status in the transition to LM.
		Bhasin (2008)	Theoretical	Development of a dynamic multi-dimensional performance framework in order to sustain the results derived from LM. 38 indicators and 5 key dimensions: financial, customer/market, process, people and future.
		Hines et al. (2008)	Theoretical	Identification of key determinants for sustaining LM results. It is crucial to address jointly both the less visible (strategy and its deployment, management leadership, behaviour and commitment of all company members) and the more visible (process management, and LM technologies, tools

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Topics	Lines of research	Author/s	Area of application	Key contribution
		Fullerton and Wempe (2009)	Multisectoral	Impact of LM (operating and financial results). The use of non-financial indicators (operating) influences on the LM-financial performance relationship. It is therefore necessary to use appropriate non-financial metrics frameworks to sustain LM benefits.
		Ho (2010)	Multisectoral	Development of an integrated model for achieving sustainable results. This integrates ISO 9000, ISO 14001, OHSAS 18001, and Six Sigma issues. Assessment model.
		Sawhney et al. (2010)	Theoretical	Development of an integrated reliability model in order to sustain Lean results. Model based on Failure Mode and Effects Analysis (FMEA). Critical factors for sustaining LM: personnel, equipment, materials, and schedules.
		Turesky and Connell (2010)	Automotive	Identification of facilitator and inhibitor factors during different phases of LM transition. Crucial factors during the sustainability of LM results stage.
	Social Sustainability	Kamata (1982)	Automotive	Study of working conditions in TPS factories. There are some negative consequences such as work intensification, loss of autonomy and increased stress. However, LM puts a greater emphasis on safety issues (e.g., it prevents repetitive strain injuries). Lack of commitment of seasonal workers.
		Schonberger (1986)	Multisectoral	Assessment of possible trade-offs between LM and social conditions. LM increases job variety giving the worker additional work tasks; however, this job enlargement is conducive to beneficial ergonomic effects.
		Forrester (1995)	Theoretical	LM implies more responsibilities for people and the work can be more intense and stressful (vulnerable system – less inventory/buffers).
		Niepce and Molleman (1996)	Automotive	Theoretical comparison between socio-technical systems and LM. Criticisms related to work standardisation (less worker autonomy), unbuffered flow implies stress and less freedom of movement, hierarchical team leaders. However, LM allows improved social relationships to satisfy the needs of people.
		Pil and MacDuffie (1996)	Automotive	LM requires a high participation of people in work organisation practices. However, effect of downsizing and/or seasonal workers can damage the psychological contract between employee and company (lack of people commitment).
		Green (1999)	Theoretical	There are some criticisms of the social weakness of LM, such as: poor safety standards, stress, loss of individual freedom, excessive control, and even exploitation.
		Biazzo and Panizzolo (2000)	Theoretical	Evaluation of the change in Lean work organisation from the worker's perspective. Some problems related to a lower quality of life for workers, such as mechanisms of social control, weakening of the unions, intensification of work and stress.
		Suzuki (2004)	Theoretical	Theoretical comparison between Japanese Production System and LM. LM could lead to an increase in stress due to the low inventory levels (production pace), high pressure on workers and, subsequently, a lower quality of life for workers.
		de Treville et al. (2005)	Theoretical	Study of the impact of LM on worker autonomy, mainly focussing on LM Standard Operating Procedures (SOP). LM can generate intrinsic motivation and increased responsible autonomy. However, there are some inhibitor factors: production pressures, high capacity utilisation, and lack of management support.
		Conti et al. (2006)	Multisectoral	Empirical study of work conditions in an LM environment. Mainly focuses on the relationship between LM and worker job stress (physical and mental). LM is not inherently stressful; however, stress levels are significantly related to management decisions in designing and operating LM systems (degree of LM implementation).
		de Treville and Antonakis (2006)	Theoretical	Study of the relationship between job characteristics and motivational outcomes in an LM environment. LM job design may engender worker intrinsic motivation; however, it may be limited by excessive leanness (depending on LM configurations: feedback, task identity, skill variety, work facilitation, and responsible autonomy).
		Fliedner and Majeske (2010)	Theoretical	Imperious necessity to adopt a social responsibility and employee satisfaction approach in LM theory in order to improve social conditions.
		Taubitz (2010)	Theoretical	Theoretical guide for integrating LM, Green and Safety issues. Lean culture is a driver of the adoption of Safety

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Topics	Lines of research	Author/s	Area of application	Key contribution
				initiatives since as other things, injury and illness are considered as waste. It is crucial to consider safety and health as cornerstones of LM theory.
		Vinodh et al. (2011)	Theoretical	Development of a methodology for the transition from 5S to 7S with the aim of integrating several issues relating to people's health and safety.
Lean Supply Chain Management and Sustainability	Environmental Sustainability	Florida (1996)	Multisectoral	Positive effect of LSCM (facilitator) on the adoption of environmental practices across the supply chain and, subsequently, on SC environmental performance.
		Simons and Mason (2003)	Theoretical	Adaptation of VSM for its integration into environmental principles and practices. Internal and external LM focus.
		Simpson and Power (2005)	Automotive	Positive effect of LSCM (mainly by Lean supplier development policies) on the adoption of environmental practices across the supply chain and, subsequently, on SC environmental performance.
		Corbett and Klassen (2006)	Theoretical	LSCM acts as a facilitator for adopting environmental practices across the supply chain.
		Mason et al. (2008)	Theoretical	Adaptation of VSM for its integration into environmental principles and practices. Greater extension to the supply chain management.
		Mollenkopf et al. (2010)	Theoretical	Literature review of drivers, barriers, synergies and conflicts between LM, Green and Global Supply Chain initiatives.
		Carvalho et al. (2011)	Theoretical	Literature review of potential synergies and conflicts between LM and Green from both an internal and Supply Chain focuses.
		Dües et al. (2013)	Theoretical	Literature review of potential synergies and conflicts between Lean and Green Supply Chain Management (focussing on practices). LSCM acts as a catalyst that facilitates GSCM implementation. In turn, GSCM practices have a positive influence on existing LSCM practices.
	Economic Sustainability	Hines (1996)	Theoretical	Identification of key determinants. A strategic approach is necessary rather than an operative approach. Importance of continuous improvement of collaborative relationships. Crucial role of Lean supplier development policies and exchange of personnel between SC partners. Lack of consideration of human aspects.
		Arkader (2001)	Automotive	Identification of inhibitors. Narrow focus on upstream relationships, mainly on tier 1 suppliers. Lack of a strategic approach (focuses on operative issues). It is crucial to assess prior inter-organisational relationships and contextual factors in LSCM sustainability.
		Smith and Tranfield (2005)	Aerospace	Identification of key determinants. It is crucial to adopt Lean supplier development policies. Main problem: power structures (domination) in the SC. It is therefore crucial to adopt the principle of equal partners from the outset. Role of SC Structure (not only focussing on achieving cost reductions).
		Comm and Mathaisel (2008)	Service	Identification of key determinants. Emphasis on effective collaboration, appropriate IT and outsourcing policies between SC partners. Integration efforts have to be improved continuously. Consideration of the role of SC Structure.
		Wee and Wu (2009)	Automotive	Identification of key determinant for achieving a sustainable LSCM strategy and development of a methodology for joint supplier-customer problem solving. Stresses the continuous use of Value Stream Mapping along with PDCA cycle. It is crucial to adopt a strategic and human approach. Main problem: overproduction along the supply chain.
		Fliedner and Majeske (2010)	Theoretical	Imperious necessity to adopt integrated sustainability considering its three dimensions and extending these to Lean supply chain management.

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