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Lean Manufacturing in Continuous Manufacturing Systems: A Literature Review

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ABSTRACT

Lean manufacturing (LM) is one of the largest approaches used for waste reduction in industrial segments. Its origin is based in the Toyota Production System(TPS),initially being applied to big companies and operating under discrete manufacturing(DM) systems.The purpose of this paper is to conduct one methodology for literature review focused in small enterprises (SE) andin continuous manufacturing(CM) systems. This work intends to cover a gap presented by former papers, since literature review, regarding LM in continuous manufacturing systems,is rare.A systematic review methodology was employed, covering:planning,conducting and dissemination. As a result, this study intendsto be a researchers' guide for future research focused on LM in CM systems.

Keywords: *Literature review, Lean Manufacturing, Small enterprises, Continuous manufacturing.*

INTRODUCTION

The current global market is characterized by a strong competition in price, mainly for following the commodities' market and their pricing. Companies are looking for customized products and have worked hard in planning improvements and developing cost reduction tools.

Lean manufacturing (LM) is a production concept that originated in Japan, which main goal is waste reduction in the manufacturing process. LM started in DM systems, mainly in the automotive enterprises. The first approach in the discrete systems was cost reduction and quality improvement. Many papers have described a range of benefits with LM implementation, such as: reduction in lead time, work in process (WIP) and manufacturing time, elimination of super production and cost reduction in inventory.

The first time the term 'lean' was accurately mentioned was in the book '*The Machine that Changed the World'* and in the beginning of 1990s the LM concept became the most attractive alternative manufacturing philosophy for mass production (Womack *et al.*, 1990).The other approach used was called The Toyota Production System or TPS which regards to the Japanese production system (Ohno, 1988; Spear and Bowen, 1999). The movement that started in the manufacturing sector has now achieved new dimensions in other sectors like software coding, healthcare, construction, process, etc.

LMliterature focused on DM systems is rare, especially research that cover the continuous manufacturing (CM) system mainly in small enterprise (SE).

The paper is structured as: Section 2 presents the literature review, section 3 the methodology used to conduct the work, sections 4 and 5 treat the data results and their analysis. Section 6 presents the conclusion.

Literature Review

LM literature review started in the 1980's, when the first approach was related to the Toyota Production System (TPS), whose author was TaichiOhno (Ohno, 1988). Waste removal, inventory reduction and productivity improvement are the pillars of the Just-in-Time (JIT) and Jidoka (Ohno, 1988; Liker, 2004).The first authors focused in the JIT part due to the measurable targets (Monden 1983, Pettersen, 2009).The concept of Jidoka appeared as an alternative for TPS when the quality and productivity become goals to be reached.

Another TPS concept was described in the article "Triumph of the Lean production system" by Krafcik (1989).The point that marked the LM history was the launch of the book *The Machine That Changed the World* by Womack and Jones in1990 by stablishing the LM denomination to the assembly of concepts and tools involved in the TPS.LM in accordance to Liker (1996) was a tool to eliminate waste and create a production flow more streamlined and more productive.

In the past 20 years, the global market story line has changed progressively, enterprises, including small and medium enterprises (SMEs) left mass production, starting to execute the "lean philosophy" (Womack et al., 1990). Mass production was put into action in a market with high request and minimum personalization of products (Chiarini, 2012). Now, in the era of high personalization of products and services (Goleman et al., 2001), enterprises necessitate to reduce costs and waste through their productive activities (Chiarini, 2012).

The ambition of lean thinking (LT) is to eliminate non-necessary processes, boost productivity, improve quality and shorten lead times, but also reduce overall cost (Karlsson and Åhlström 1996; Sohal 1996; Ghosh 2013). In literature, the concept of "Lean" has been interpreted in many different forms (Arlbjørn and Freytag 2013). Hines et al. (2004) propose that Leanhas both strategic and operational dimensions. Shah and Ward (2007) define itas a conjunction of practical and philosophical directions, leveled in three classifications: philosophy, principles and tools and techniques (Arlbjørn et al., 2008; Ghosh, 2013). Respectively, the first level is considered the philosophical level, which expresses central concern of Lean to eliminate wastes and upgrade client value (Radnor, 2000; Hines et al., 2004, Shaw and Ward, 2007).

The second level is based in production related principles (Hines et al., 2004). For instance, Womack and Jones (1996) point five principal propositions of LT: value, stream, flow, pull and perfection. Lyons et al. (2011) describe that with constructive involvement of company employees, it is possible to pursue continuous improvement utilizing these principles, through identifying non-value-added activities by creating and analyzing value stream and aligning the production with demand-pull systems.

The third level is characterized as the operational level, the collection of lean tools that facilities the action needed to achieve goals directed by different lean principles (Hines et al., 2004). For example, lean practices such as, 5S, total productive maintenance (TPM), value stream mapping (VSM), visual control, work standardization, mistake proofing help to eradicate waste, whereas Kanban, pull production and production leveling are responsible for aligning production with demand (Panwar et al., 2015).Techniques such as kaizen, job rotation and cross-functional teams collaborate to continuous improvements (Panwar et al., 2015). A vast diversity of lean practices can be found on existent literature (Womack and Jones, 1996; Shah and Ward, 2003; Anand and Kodali 2009).

Tools such as value stream mapping techniques support to identify waste in value stream, and hence, find a good manner to achieve the removing, or at least reduction, of waste (Dhandapani et al., 2004). Rother and Shook (1999) affirm that VSM is an easy understanding tool which allows simultaneous representation of the information and material flow. Waste is something which is not value added activity to the final product or customers (Kodali, 2014). The concept of waste includes all possible defective work or activities and not only limited to defective products (Tajand Berro, 2006). Monden (1983) distinct three kinds of operation in manufacturing:

- non-value adding (NVA);
- necessary but non-value adding (NNVA);
- value-adding (VA).

The first of these is pure waste and involves unnecessary actions, which should be eliminated completely. Necessary but non-value adding operations may be wasteful but are necessary under the current operating procedures. Value-adding operations involve the conversion or processing of raw materials or semi-finished products through labor (Hines and Rich, 1997).

Ohno classifies waste into seven categories (Monden, 1993):

1) over production;
2) waiting;

3) transportation;
4) inappropriate processing;
5) unnecessary inventory;
6) unnecessary motions; and
7) defects.

Despite the larger organizations predominately first try to turn their production to a Lean production (Shah and Ward, 2003), Lean has been every time considered as a must key for upgrading processes for all kinds of enterprises (Hu et al., 2015). Presently, large firms are more likely to implement lean practices than their smaller counterparts (Powell et al., 2013).

According do Dora et al.(2013), LM is essential for small and medium enterprises (SMEs). The implementation of LM can bring a huge diversity of benefits, such as, quality upgrading, reduction of cycle time and more responsiveness (Spann et al., 1999). Although, there are some critical factors for why LM is not much implemented in SMEs, the same way it is necessary in large enterprises (LE). The high investment of money, time and effort related to the implementation of LM versions could be seen as out of the budgets of SMES. Some researchers, as Brown and Inman (1993), highlight factors such as, lack of top management compromise, limited financial resources, investment in specialized equipment, and a poor perception that lean production is a simpler way of manufacturing control. Another issue could be the low power of influence in the supply chain, with less power to bargain prices or dictate sale prices for customers (Hu et al., 2015).In SMEs, due to low seen benefits of Lean installation, management is often hesitant to invest, due alsoto the high consultant fees (Panizzolo ET AL, 2012). Moreover, SMEs, by virtue of their size, are constrained by a number of key factors that include a lack of adequate funding and leadership deficiencies (Achanga et al., 2004, 2005a, b). According to Hu et al. (2015), a leader should be able and strong for a successful implementation of LM.

A resolution proposal of LM high costs implementation is presented by Lee (2004), who affirms that SMEs need to focus on elements that are less expensive like 5S, quality circle, preventive maintenance and employee involvement to reach their goals. Rothenberg (2004), advices that SMEs need to start with minimal financial investment on Lean, such as 5S, Kanban and Honshin.

A lot of studies about Lean practices have been done in the past, showing every time, its efficiency. However, most application cases are based in the discrete manufacturing (or discontinuous). Tubino (2000) classifies this processes line that involves the production of isolated goods and services, in lots or units, and identified in relation to others. Initially, Lean methodology was idealized for the discrete industry, with high volume and low variety (Womack et al,; Keller and Kazazi, 1993; Oliver, Delbridge, and Lowe 1996; Womack and Jones 1996; Liker, 1997; Taj, 2008), which characterizes Toyota, the enterprise of its origin. Although, lean support declaring that lean can be implemented in a wide range of industries, acting under diverse environments (Ohno, 1988; Billesbach, 1994; Womack and Jones 1996). In fact, lean has been tried in several sectors (Robertson and Jones, 1999; Storch and Lim, 1999; Dunlop and Smith, 2004; Radnor et al. 2006). Stone (2012) states that after four decades of evolution, lean gradually gained applicability across numerous industries and sectors, beyond the automotive sector. However, many researchers doubt the adaptability of lean for manufacturing setups different from the Japanese automotive sector (Berggren, 1993; Jorgensen and Emmitt 2008; Pettersen 2009), that is, with high-volume and unvaried setups (Hines et al., 2004).

Several researchers highlight a relevant deficit in literature on process industry applications of LM (Abdulmalek and Rajgopal, 2007; Gebauer et al., 2009; Jain and Lyons, 2009; Gupta et al., 2013). According to Dennis and Meredith (2000), process industries are industries such as mixing, separating, forming and chemical reactions. They include huge inflexible machines, long setup times and generally difficulty in batching (Abdulmalek and Rajgopal, 2007).For Ashayeri et al. (1996), process industry is further characterized by expensive equipment, strict environmental considerations and a high degree of automation. Gunasekaran (1998) describes that despite the fact that both DM industry and process industry have the same objectives and that the process industry has not been quick to embrace the lean manufacturing concept. Researchers, such as, Storck and Lindberg (2007), who are in the steel strip production sector, it demonstrates that the LM tools for setup reductions have not got the same attention in comparison to what has become the state of art in the automotive and manufacturing industries. It has been argued that in some measure, this is because such industries are inherently more efficient and have a relatively less urgent need for major improvement activities (Abdulmalek and Rajgopal, 2007).According to King (2009), the installation of LM is not straight forward in the process industries due to typical operational characteristics, for example: process industries have continuous flow of material, very large, inflexible and fixed capacity equipments, process dependence on time and temperature, and high volumes with less variety of products (Crama et al., 2001).

Sometimes, processes are really continuous, in the sense that the products are inseparable and produced by uninterrupted flow (Slack et al., 2002). Abdullah et al. (2002) affirm that despite the usual classification of an industry about being purely continuous or purely discrete, all the production systems are, in fact, hybrid. Authors say that “non-discrete unities” can become discrete in any moment of production. One example is the hybrid continuous production of beverage by fermentation reactors and pipelines. However, this process stays discrete until it is bottled in cylinders for commercialization.

It costs a lot for continuous processes industries to stop a great process, which could create a big restriction in the logistics point of view. The process interruptions, for anomalies detection or by the imposition of smaller lots, are the challenges in adaptation and implementation of the lean philosophy in continuous processes environments. Few academic works talk about lean production in CM environments, Billesbach (1994) reports the case in DuPont factory in the USA, where textile fibers were produced in a continuous wiring process that passed by an implementation of a pull system. Abdullah (2003), Abdulmalek and Rajgopal (2007) produced an interesting work by investigating the use of LM tools and techniques in continuous production environments, particularly in the steel industry. Authors, using the study in an US steel manufacturer company, have drawn the current state map based on real data collected. Abdullah (2003) points out just-in-time tools and heijunka (production leveling) as partially applicable to that continuous industry. The "manufacturing cells" tool is classified as a very difficult adjustment while "setup reduction", "value stream mapping", "TPM" and "visual management" would be universally applicable. Ahmad et al. (2005), Melton (2005), Cook and Rogowski (1996) and Abdulmalek et al. (2006) assess aspects of the continuous manufacturing that are malleable to lean tools and present a classification method to guide lean implementation in process industries.

Moreover, managers still feel suspicious about the validity of lean manufacturing in the process industry environment (Melton, 2005).A Libyan study about iron and steel industries, Hokoma et al. (2010) describes the following reasons to the non- implementation of TQM/JIT techniques on process industries:

- Lack of senior management support – 11.1 percent;
- Lack of interest within the companies – 11.1 percent;
- The implementation requires formal approval – 0.0 percent;
- TQM/JIT/MRPII does not fit well with the company – 0.0 percent;
- The company is not familiar with TQM/JIT/MRPII – 77.8 percent;
- TQM/JIT/MRPII is too expensive to implement – 0.0 percent; and
- TQM/JIT/MRPII is too complex to implement – 0.0 percent.

Sewig (2008) complements Melton (2005) and describes that resistance to change and confusion on validity are to be surmounted while process industries implement lean. Another difficulty in implementing lean is the difficult to find leaders to guide the change (Kamakura, 2006).Moreover, process industries have an important scope for improvements based on LM concepts, like inventory control, waste elimination, quality management, continuous improvements and customer satisfaction (Mady, 1991; Koumanakos, 2008; Gebauer et al., 2009). Panwar et al. (2013) considers interesting to investigate a philosophy designed for discrete manufacturing extending its applicability in process industries.

The usage of Lean in the textile industry has not been reported yet (Karthi et al., 2013). Nevertheless, some researchers have published academic articles highlighting the application of LM in this kind of industry. Hodge et al. (2011) have applied LM principles in a composite textile mill having weaving and wet processing and formulated a scheme about VSM application. They found that visual controls are frequently used, despite LM principles being new to the textile sector. Textile and clothing sales are expected to achieve US$ 1 Trillion by 2020, starting from the level of US$ 510 billion in 2013 Karthi et al. (2013) and need to achieve a sustained growth rate, supported by tools and techniques, such as lean. Bhamu and Sagwan (2014) identify only three important publications in textile sector, showing that the area is underexploited. Hodge et al. (2011) state that lean is not widespread in textile companies, but conclude that lean should be adaptable for the textile industry.

Comm and Mathaisel (2005) make the suggestion that lean fits a textile context, demonstrating that lean is both applicable for business performance upgrading and supply chain level. The results show the general effect perception associated with lean actions in a business point of view. Most studies about lean in the textile sector have the main discussions focused at the supply chain level (Manfredsson, 2016). Bruce et al. (2004) contradicts these researches, claiming that lean is not a good approach for a textile value chain, and Christopher (2000), who claims that agile manufacturing is the best choice for supply chains, based on the changeable necessities in the fashion market. Bruce et al. (2004) continue their theory that a mix of agile and lean would work well. The different conclusions match the viewpoint of Mason-Jones et al. (2000), these researchers claim that lean could be utilized as an initial point for agile systems, so the different points of view discussed earlier could, in the future, converge. Manfredsson (2016) compiles these different ideas and concludes that with supply chain and business development agility will, also, be enabled.

Nevertheless, similar to other areas of the economy, the employee involvement dimension is not approached in the debate, neither its impact in the textile context (Manfredsson, 2016). Hodge et al. (2011) discusses parts of the employee perspective as implementation barriers and cultural changes. Arlbjorn et al. (2011) suggest a focus on customer satisfaction and certain tools. In this case, even if there is a suggestion of an application of a fit lean framework in the business and supply chain dimension, a gap still needs to be breached, that is human involvement (Manfredsson, 2016). This aspect suggests that human capital is one key point to the textile enterprises success, mainly to SE (Adinolfi and Andersen, 2011). Moreover, Edmans (2011) suggests that both employee and business perspectives need to be evaluated to enhance lean in a textile segment.

METHOD

This work started researching literatures refereeing to the concepts definition and practical application of lean production (LP), consulting the followed portals: Emerald, Science Direct, Springer Link and Francis. The research chose the year 1989 as the starting point. Key words used were: Lean production (LP),Lean manufacturing (LM), and Lean supply chain (LSC),Lean product development (LPD), Lean enterprise (LE),Small enterprise (SE),Continuous manufacturing (CM).Some authors were used as reference for this work design, such as Anand (2009) and Jasti and Kodali (2015).The redundancies were removed and in the beginning, 218 articles were founded, and focusing on SE and CM, a list of 61 articles shared in 32 journals are shown in Table 1.

MAIN ANALYSIS AND RESULTS FROM THE LITERATURE RESEARCH

Time Distribution of Publication of Articles

The first performed analysis considered the most important journals worldwide, which presents LM as a production methodology. Table 1shows 32 journals considered in this study, as well as, the percentage of each journal. The study brought an analysis of the years in which the articles were published, aiming to analyze the trend of academic research over the years. The revised articles were published from 1989 to 2016. Most articles were published in the last two decades, mainly between 2000 and 2016, 73.77% of the research was published in this period. The year 2013 has the highest number (6) of published articles and in sequence, 1996 and 2004 have five articles. IJOPM, PPC, JMTM and IJPR constitute about 40% of the reviewed articles in this review, with IJOPM being the major publisher, with nine.

Table 2 illustrates the number of articles published in LP, well scattered over the years, but after 2004, the number has increased, with 40 articles been published. IJSOM has published the highest number of articles in any year (3).

Table1. *List of selected journals considered in current study*

Journal Name	Acronym	No. of Articles	%
International Journal of Operations and Production Management	IJOPM	9	14.75
International Journal of Production Research	IJPR	4	6.56
International Journal of Production Economics	IJPE	1	1.64
Journal of Manufacturing Technology Management	JMTM	5	8.20
International Journal of Quality & Reliability Management	IJQRM	1	1.64
Production Planning & Control	PPC	6	9.84
Journal of Operations Management	JOM	1	1.64
International Journal of Logistics Research and Applications	IJLRA	1	1.64
International Journal of Services and Operations Management	IJSOM	3	4.92
International Journal of Productivity and Performance Management	IJPPM	3	4.92
Industrial Management and Data Systems	IMDS	1	1.64
British Journal of Management	BJM	1	1.64
Production and Inventory Management Journal	P&IMJ	2	3.28
International Journal of Lean Six Sigma	IJSS	1	1.64
International Journal of Agile Management Systems	IJAMS	2	3.28
Engineering, Construction and Architectural Management	ECAM	2	3.28
Work, Employment and Society	WES	1	1.64
The TQM Journal	TQMJ	1	1.64
Journal of Operations Management	JOM	3	4.92
Chemical Engineering Research & Design	CERD	1	1.64
The Journal of The Textile Institute	TJTI	1	1.64
Drug Discovery Today: Technologies	DDT	1	1.64
Technology Review	TR	1	1.64
Benchmarking: An International Journal	BIJ	1	1.64
Engineering Management Journal	EMJ	1	1.64
Asia Pacific Journal of Marketing and Logistics	APJML	1	1.64
International Journal of Physical Distribution and Logistics Management	IJPDLM	1	1.64
Industrial Marketing Management	IMM	1	1.64
Robotics and Computer-Integrated Manufacturing	RCIM	1	1.64
Journal of Financial Economics	JFC	1	1.64
Trends in Food Science & Technology	TFST	1	1.64
International Journal of Manufacturing Technology and Management	IJMTM	1	1.64
Total		61	100

Table2. *Year-wise frequency distribution of articles*

Journal name	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	No.of articles	%
IJOPM			1		1			2	1							2										2			9	14.7541
IJPR								1		1												1			1				4	6.557377
IJPE																			1										1	1.639344
JMTM																				1				1	1		2		5	8.196721
IJQRM																1													1	1.639344
PPC											1												2	1			1	1	6	9.836066
JOM															1														1	1.639344
IJLRA																1													1	1.639344
IJSOM																					3								3	4.918033
IJPPM																		1		1					1				3	4.918033
IMDS					1																								1	1.639344
BJM								1																					1	1.639344
P&IMJ						1		1																					2	3.278689
IJSS																								1					1	1.639344
IJAMS											1	1																	2	3.278689
ECAM																1				1									2	3.278689
WES					1																								1	1.639344
TQMJ																						1							1	1.639344
JOM												1			1				1										3	4.918033
CERD																	1												1	1.639344
TJTI																									1				1	1.639344
DDT																				1									1	1.639344
TR	1																												1	1.639344
BIJ																									1				1	1.639344
EMJ																		1											1	1.639344
APJML																	1												1	1.639344
IJPDLM																							1						1	1.639344
IMM												1																	1	1.639344
RCIM																	1												1	1.639344
JFC																							1						1	1.639344
TFST																									1				1	1.639344
IJMTM												1																	1	1.639344
Total	1	0	1	0	3	1	0	5	1	1	2	4	0	0	2	5	3	2	2	4	3	2	4	3	6	2	3	1	61	100

Description of the Research Methodologies

After consulting Dangayach and Deshmukh (2001), this work's nature was classified in the following categories:

- Conceptual – basic LP conception articles;
- Descriptive – explanation or description of LP and performance issues;
- Empirical – applies qualitative approaches;
- Exploratory cross sectional – demands data acquisition using survey but the information gathered is at one point in time only;
- Exploratory longitudinal –uses data collection using survey at two or more points over a period of time.

According to the applied research methodology and the time period, Table 3 was constructed.

Table3. *Research methodologies and the distribution of the articles*

Researchmethodology	1989 - 1999	2000 - 2016	Number of papers	%
Conceptual	3	13	16	26.23
Descriptive	3	9	12	19,67
Empirical	3	18	21	34.43
Exploratorycross-sectional	2		9	14.75
Exploratory longitudinal	1	2	3	4.92
Total	12	49	61	100
Note:Chi-square , p< 0.04				

Study of Trends for Authorship

Table 4 shows the authorship trends by countries and continents. From 1989 to 1999, 10 countries published collaboration researchers. The United States and the United Kingdom were the countries with the most written articles, leading research among these ten countries. In the first period, the USA had more articles than the UK, a condition that was reversed in the second period. Europe was the most productive continent in the first and second periods, followed by North America and Asia, respectively obtaining44.26%, 24.59% and 9.84% of representations. In intercontinental research, considerable integration among researchers from different continents was noted: Africa-Europe, Asia-Europe, Asia-North America and Europe-Asia-North America represented 18.03% of the published papers. Asia-North America presented 8.20%.

Table4. *Trends of authorship by countries and continents.*

Countries and continents	1989-1999	2000-2016	Total	%
Africa	1	0	1	1.64
Egypt	1	0	1	
Africa-Europe	0	1	1	1.64
Lybia, UK	0	1	1	
Asia	0	6	6	9.84
India	0	6	6	
Asia-Europe	1	3	4	6.56
Italy, India	0	1	1	
UK, India	0	2	2	
UK, Iran	1	0	1	
Asia-North America	1	4	5	8.20
USA, Korea	1	0	1	
USA, Kuwait	0	2	2	
India, USA	0	2	2	
Australia	1	0	1	1.64
Europe	7	20	27	44.26
Belgium, UK	0	1	1	
Denmark	0	3	3	
Denmark, UK	0	1	1	
Greece	0	1	1	
Italy	0	1	1	
Netherlands, Belgium	1	0	1	
Norway, Netherlands	0	1	1	
Sweden	2	2	4	
Switzerland	1	0	1	
UK	3	10	13	
Europe-Asia-North America	0	1	1	1.64
UK, India, USA	0	1	1	
North America	4	11	15	24.59
USA	4	11	15	
Total			**61**	**100**

Table 5 shows authorship pattern of the selected articles. It shows that the number of authors per article has grown after the turn of the century. There was an increase in the three forms of authorship, but it was more evidenced in articles with more than two authors, having 18 articles more than the first period. The multi-authored studies are predominant (42 of 61), which evidences the mutual cooperation among the authors.

Table5. *Authorship Pattern*

Number of authors	1988-1999	2000-2016	Total
One (single author)	6	13	19
Two	7	11	18
More than two	3	21	24
Total of multi -author	10	32	42
Total	**16**	**45**	**61**

Note: Chi-square, p<0.02

Sector-Wise Focused of the Article

In this sector, the study seeks to show which sectors were the most privileged by the researchers of the evaluated articles. As the concept of lean is not only restricted to the automobile industry, but for all kinds of industries (Crute et al., 2003), the frequency of other types of industry in the literary review was accounted for. Thus, it is explicit the spread of lean philosophy among companies, such as chemical, aerospace, electronics and the service sector (Bowen and Youngdahl, 1998; Atkinson, 2004; Abdi et al., 2006).

In addition to the application sectors, the articles were classified among those that focused on discrete production systems, and those that studied continuous and processes system, as shown in Table 6.It was evident the great discrepancy of the number of works in continuous systems, in relation to the ones that prioritized discrete systems. Papers that worked with more than one sector of the industry at the same time had a larger quantity, accounting for 27.87% of the total, the textile and chemical industries followed with 9.84% and 6.56% of the academic literary selection of this paper. Continuous systems have only 15 of the 61 articles (22.95%) of the literary review selected for analysis in section 4, showing a possibility for further investigation in this subject. 26.23% of them did not focus on any sector, approaching lean manufacturing in a more general way. Electronic, naval, service and telecommunication were the less studied kinds of industries with only one article each (1.64%). Table 6 shows the frequency distribution considering CM and DM obtained from the total of papers researched for this study.

Table6. *Frequency of sector type distribution and their application in manufacturing systems.*

	Kind of system			
Industry	Continuous/Process	Discrete	Total	%
Multiple	7	10	17	27.87
Textile	1	5	6	9.84
Chemical	2	2	4	6.56
Automobile	0	3	3	4.92
Manufacturing	2	1	3	4.92
Auto components	0	2	2	3.28
Construction	0	2	2	3.28
Food Processing	0	2	2	3.28
Pharmaceutical	0	2	2	3.28
Electronic	0	1	1	1.64
Naval	0	1	1	1.64
Service	0	1	1	1.64
Telecommunication	0	1	1	1.64
None	2	14	16	26.23
Grand total	**14**	**47**	**61**	**100**

According to Table 7, over the years, the frequency of articles in continuous systems is flawed. In the period between 2001 and 2004, there is no occurrence of any paper addressing the subject. The years 1996, 2010 and 2015 only had 2 articles. After the year 2000, there was a growth in research in this branch, having 10 of the 14 works published in that year. However, no relationship of authorship growth has been observed in the last 5 years. This reason justifies the necessity to invest more time, resource and workforce to increase the knowledge of this topic and clarify misconceptions and implement some of the theories into practice.

Table7. *Time distribution of continuous/processes systems' articles over the years and their occurrence.*

Years	Number of ocurrences
1991	1
1992	0
1993	
1994	1
1995	0
1996	2
1997	
1998	
1999	
2000	1
2001	
2002	
2003	
2004	
2005	1
2006	1
2007	1
2008	1
2009	
2010	2
2011	
2012	
2013	1
2014	
2015	2
Total	**14**

Research Articles Focusing on LM Waste on Continuous/ Processes Systems

The main purpose of LM is manufacturing the products without any kind of waste. The study sought to organize an investigation of the most focused waste in the 15 selected articles that focused their investigations on processes/ continuous systems as shown in Table 8. The most recurrent waste was inventory waste, showing that continuous systems frequently get this kind of problem, due to its inflexible production. 4 articles dealt with waste of lean in a general way, dealing with literary reviews, and not focusing on a specific problem.

Table8. *Lean waste and their frequency of occurrence*

Lean waste	Frequence of ocurrence
Inventory	8
Waiting time	4
Inapropriate processing	1
Over production	1
Unnecessary motion	1

Research Articles Focused on LM Elements Applied to Continuous System and Processes Systems

The study went further and sought among publishers which elements were most used widely in lean manufacturing publications in academia. Articles which focus was to carry out a literary review on his portfolio were excluded because they were a synthesis and did not have a specific focus on lean tools, making general analyzes of what had already been written in the subject. Excluding literary review articles, the tools used by the remaining articles were JIT production, pull production, TPM, setup reduction, VSM, visual manufacturing, 5S, and waste elimination. Table 9 indicates each tool occurrence.

The most popular tools are elimination of waste and JIT production (12.63%). These results demonstrate that the organizations studied in the evaluated articles sought loss reduction in their productive activities, seeking to maximize profits. With JIT production tools, they have sought to reduce their inventories and produce only what is needed by the consumer. Visual factory, setup reduction and 5S were the least recurring tools.

Table9. *Lean tools and their frequency of occurrence*

Lean tools	Frequence of ocurrence
Waste elimination	6
JIT roduction	3
VSM	2
TPM	2
5S	1
Setup reduction	1
Visual factory	1

Framework/Models of LM in Continuous/ Processes Industries

The study's focus also wanted to know the researcher's focus in developing models and frameworks in continuous/processes industries to achieve the organizational performance. The frameworks and models are distributed between the research streams in this kind of industry. Table 10 shows the frequency of framework/status with respect to research streams that were lean manufacturing and lean supply chain only. In the 14 articles in this kind of industry, only 10 had proposed frameworks/models in their environment. 3 of them proposed and implemented a frame work, and those who did it, also measured the performance of the system after implementation. Those who proposed framework/model had the highest number, with 5 occurrences.

Table10. *Frequency of frameworks /models with respect to research streams*

Research streams	Proposed frame work/model	Proposed model	Proposed and implemented frame work	Proposed and implemented implemented model	Performance measurement	Total
Lean manufacturing	5	2	2	0	2	9
Lean supply chain	0	0	1	0	1	1
Total	**5**	**2**	**3**	**0**	**3**	**10**

Discussions

Considering all the figures presented in this current paper, as well as the base of 32 journals researched in its construction, some important findings are presented as follow:

5.1-During the period of 17 years the journal more mentioned in the LM research was the IJOPM with 14.75% of the total analyzed in this study;

5.2-The frequency of the papers about LM increased dramatically from years 2000 and 2016,showing the importance of this subject in the organizations;

5.3-Europe is leading the rank of continents with literature regarded LM;

5.4-The study shows that DM system for multiple market segment is responsible for 27.87% of the total of papers researched;

5.5-Waste elimination was the LM tool with the biggest frequency among the studies analyzed;

5.6-Regarded to research streams, LM had the highest frequency considering the framework and model

Conclusion

The research shows that the literature regarding LM has been grown over 27 years. The study can suggest that the empirical methodology is the biggest approach for papers. As shown in this paper, the increasing in the number of papers regarding LM is led by Europe, followed by North America. It is possible to observe that the authorship is conducted by the multi-author articles. The study presented in this paper strongly supports the hypothesis that the literature describing the LM application for the CM in the textile segment are really rare, and that the big frequency of waste is due to the inventory in this kind of manufacturing system.

Considering the results of this study, it is possible to adopt the suggestion for future works which could analyze the LM tools application for CM systems in the textile segment.

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