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How far from Lean are Portuguese Manufacturing Small and Medium Enterprises?

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Abstract

Purpose – The purpose of this study is to canvass to what extent Lean practices are being implemented in Portuguese manufacturing Small and Medium Enterprises (SMEs), and in which way these practices are affecting their performances.

Design/methodology/approach – An on-line questionnaire was distributed among X (y% response rate) Portuguese organizations that fitted in the category of Small and Medium Enterprises and that belong to the manufacturing sector (companies with code 10 to 32 according to NACE Rev. 2 classification).

Findings –

Implications – The results from the study contribute to the investigation on the topic broadening the literature on the implementation of Lean practices in companies around the world. The outcomes of the research may be used as an motivation for other Portuguese SMEs to implement Lean practices when acknowledging the impact on performance that the companies that adopted (partially or globally) this philosophy got. Moreover, the degree of Lean implementation of the Portuguese industry may constitute a signal for government and/or economic decision makers define incentives such as, fiscal benefits for companies who enter in Lean's implementation program, partly financing workers cross-training, among others.

Originality/value – This study enriches the researches made on the impact of Lean manufacturing on performance and the degree of implementation in the industry by looking over a country that has never been investigated in that topic.

Key words: Lean manufacturing; SME; Portugal; Performance; Leanness; SEM

JEL-Codes: L60; M11

Contents

1. Introduction

Lean production is a multi-dimensional system with the central objective of waste elimination through practices that minimize supplier, customer and internal variability (Shah & Ward, 2007). The concept originated in Japan gained wide attention from the moment it was introduced and many authors have even considered it as the best possible production system able to be implemented in any company (Womack *et al.*, 1990; Womack & Jones, 1996). In fact, it is acknowledged by many academics and practitioners the linkage of Lean production with superior operational performance and competitive advantage (Shah & Ward, 2003), reason why many organizations are resorting to Lean practices (Bonavia & Marin, 2006; Filho *et al.*, 2016; Pavnaskar *et al.*, 2003). There have been several surveys on its impact in different sectors and countries and therefore in diverse cultural environments. Various of those surveys have been conducted on countries such as India (Eswaramoorthi *et al.,* 2011), Italy (Panizzolo, 1998; Staudacher & Tantardini, 2007), United States of America (Shah & Ward, 2003; White *et al.*, 1999), Spain (Bonavia & Marin, 2006), United Kingdom (Achanga *et al.*, 2006), Brazil (Filho *et al.*, 2016), among others. In Portugal, there was only found a study, by Silva *et al.* (2010), that does a cross-country survey with the intention of seeing Portuguese companies' Lean journey in comparison with companies from Italy, United Kingdom and United States of America. Not assessing, nevertheless, the degree of implementation of Lean and its impact on performance.

One of the aims of this paper is to investigate how Lean are Portuguese manufacturing SMEs. Bonavia & Marin (2006) consider that there is a clamour for more studies about the implementation of Lean Production in other countries. Moreover, the focus on SMEs may outcome different results and proposals since smaller firms have different behaviour towards Lean production (Bonavia & Marin, 2006; Shah & Ward, 2003). Furthermore, according to INE, in 2015, these enterprises represented 99,92 % of the total number of enterprises in Portugal and, in the same year, these companies were responsible for more than half of the gross value added by enterprises (INE 2015). In addition, the paper also purposes to analyse the effects of Lean implementation on SMEs' performance. There are still few studies on the effect of Lean on performance of

SMEs (Filho *et al.*, 2016). In fact, no study was found presenting the outcomes of Lean manufacturing on performance of Portuguese SMEs. The present study aims to fill this gap.

This can be, therefore, considered a relevant study for two main reasons: it broadens the literature on the surveys made in the implementation of Lean practices in companies around the world; and the results may be used as an incentive and promotion for other Portuguese SMEs as well as for public economic policies such as, fiscal benefits for companies who enter in Lean's implementation program, partly financing workers cross-training, among others.

In order to accomplish those aims, a questionnaire-based survey was sent to Portuguese SMEs included in the manufacturing sector (companies with code 10 to 32 according to NACE Rev. 2 classification).

The report is divided into four sections. After the introduction, a literature review of the main topic is presented by covering its origins and the concept itself. This implies referring its principles, practices and main tools, and finally its impacts on performance. Further in the literature review it is made an analysis of similar studies, namely in different countries. In the third section it is presented the methodology being used in the study. In the fourth and last section, a chronogram of the activities and the plan of tasks until de delivery of the dissertation is presented.

2. Literature Review

In this chapter it is done a theoretical review of the main concepts related with the topic and of the relevant studies on Lean manufacturing. Firstly, it is presented the Lean's origins and the concept itself by introducing some of Lean principles, practices and wastes. Then it is introduced the evolution of the concept as well as its diffusion. This is followed by a more specific review is conducted on studies about Lean implementation made in other countries, in order to gather and analyse the contributions of similar studies that can be useful inputs for this research. Finally, measures of Lean performance and Lean implementation are reviewed.

2.1. Lean Production Origins

After World War II, Taiichi Ohno and cousins Kiichiro and Eiji Toyoda introduced *Toyota Production System* at the Toyota Motor Company (Ohno, 1988). Its basis was absolute elimination of waste through the support of two pillars: just in time and automation, as referred by Ohno (1988). This system emerged due to the fact that the concepts existent until then weren't fulfilling Japanese industry's necessities at the time (Womack *et al.*, 1990). In fact, after the World War I the age of mass production, pioneered by Henry Ford, invaded the American automobile industry and by the late 1950s this technology was being diffused all over Europe. However, despite the effort to introduce Ford's ideas into Toyota Motor Company, Japanese market's capital constraints and low volumes did not justify the large batches sizes common in mass production. (Holweg, 2007; Ohno, 1988; Womack *et al.*, 1990). A new approach needed to be made and, as cited by Ohno (1988, p.11), "The Toyota production system began when I challenged the old system".

After analysing the Western production system Taichii Ohno had found two flaws. First the excessive waste resultant from the production of large batches and second, the inability to satisfy customers' preferences for product variety (Holweg, 2007). It was in the attempt to overcome these flaws that he came up with innovations such as just-in-time, production levelling, error proofing, multi-skilled work-force, *kanban* method, etc. that integrate the *Toyota Production System* (Eswaramoorthi *et al.*, 2011; Godinho *et al.*, 2016; Hines *et al.*, 2004; Holweg, 2007; Ohno, 1988). This new production concept wasn't, though, invented all at once; Holweg (2007, p.422) defends that it was rather a "continuously interacting learning" that went for decades, and for decades was largely unnoticed.

It was only after the oil crisis in 1973, that left Japanese companies confronted with zero growth, that they started noticing Toyota's superior performance and an enormous interest was generated around the *Toyota Production System* (Ohno, 1988).

According to Hines *et al.* (2004) western manufacturers had limited knowledge on the new Japanese production system until the book *The Machine that Changed the World* highlighted this system, referring to it as "Lean production". This book was responsible for popularizing the Lean concept (Bhamu & Singh Sangwan, 2014; Holweg, 2007; Jasti & Kodali, 2015) although, for Shah & Ward (2007), it did not offer a specific definition.

2.2. Lean concept

Jasti & Kodali (2015) analysis to 546 research articles reveals that the number of publications on Lean tended to increase along the years and that in 2011 there were more than half of the articles that existed in 2000. Table 1 shows the distribution of articles along year 1993 to 2011.

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2	18	28	25	23	34	26	29	16	25	14	24	22	30	36	42	38	36	62

Table 1 – Studies on Lean from 1993 and 2011

(Adapted from Jasti & Kodali, 2015)

Despite being an intensively researched and covered topic, many are the authors who agree that there is a lack of common definition of the concept: (Bhamu *et al.*, 2014; Hines *et al.*, 2004; Karlsson & Ahlström, 1996; Shah & Ward, 2007; Pettersen, 2009).

Shah & Ward (2007, p. 791) propose as a conceptual definition that "Lean production is an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer and internal variability". But as these authors refer to it as a system, others denote it as a philosophy: "Leanness is a philosophy intended to significantly reduce cost and cycle time throughout the entire value chain while continuing to improve product performance" (Comm & Mathaisel, 2000, p.122), others as a methodology "Lean thinking is a business methodology which aims at providing a new way of thinking about how to organize human activities to deliver more benefits to society and value to individuals while eliminating waste" (Ndaita *et al.,* 2015 p.684).

Karlsson & Ahlström (1996) point out that this lack of a precise definition leads to difficulties in assessing if changes made in a company are consistent with Lean production, and therefore in appraising the effectiveness of the concept.

Bhamu & Singh Sangwan (2014) believe that this absence of common definition is due to Lean production evolution over time, in addition to a confusion between the system and its underlying components. This is also stated by Shah & Ward (2007), as they propose to solve this semantic confusion. For them, and for other authors such as Pettersen (2009), Lean is commonly described under two perspectives: philosophical and practical. However, for Shah & Ward (2007), there is a gap in the two perspectives. They propose to fill this gap by not only suggesting a conceptual definition, but also by formulating an operational measure instrument for Lean production that encompasses 10 factors measured by 48 practices/tools. This instrument, they believe, forms "a foundation for research in Lean production and should prove helpful in enabling researchers to agree on a definition" (Shah & Ward, 2007, p.801). In fact, there are some authors that have resorted to this operational measure to conduct their studies (Alsmadi *et al.*, 2012; Gelei *et al.*, 2015; Godinho Filho *et al.*, 2016; Hofer *et al.,* 2012).

2.3. Wastes' definition and classification

Lean can't be dissociated from the concept of waste. The basis of Lean manufacturing is the elimination of waste (Pavnaskar, *et al.*, 2003). Waste is stated by Jasti & Kodali (2015) as any activity that will not create any value to the final product. The customer is not willing to pay for it, and therefore should be eliminated (Karlsson & Ahlström, 1996). Ohno (1988) defined in *Toyota Production System* seven types of wastes: waste of overproduction, of waiting, of unnecessary motion, of transportation, of processing, of inventory and defects. Many authors agree with this classification of wastes and include it in their studies: (Bhasin & Burcher, 2006; Pettersen, 2009; Wahab *et al.*, 2013; Wong & Wong, 2011).

Later on, an eighth waste has been included in Ohno's original list by other authors, namely as "underutilized people" (Eswaramoorthi *et al.*, 2011; Wahab *et al.,* 2013)

2.4. Lean Principles and Tools

The philosophical perspective that is one of the perspectives under what Lean is described, is related with guiding principles and overarching goals (Shah & Ward, 2007). In fact, Lean concept can't be dissociated from its underlying principles proposed by Womack & Jones (1996). The principles are: i) specify value to the customer, ii) fully map the value-stream, iii) develop the capability to flow production, iv) let the customer "pull" the product and v) search for perfection, the happy situation of perfect value provided with zero waste (Womack & Jones 1996). Additionally, Wong & Wong (2011) consider stability, standardization and discipline as pre-requisites for Lean manufacturing.

Regarding the practical perspective of Lean, it involves describing Lean through a set of management practices and tools (Shah & Ward, 2007). This include not only the shop-floor tools developed in Toyota (*kanban*, level scheduling, takt time,…) but also other approaches whose core objective is to provide value to the customer. These approaches refer to quality, responsiveness of the manufacturing system, production capacity, demand variability, availability of production resources and production control (Hines *et al.*, 2004). Therefore, Lean encompasses a number of tools and practices developed at an operational level that help supporting the implementation of Lean thinking in organizations. There are, in fact, several Lean tools that allow companies to identify measure and/or eliminate waste (Pavnaskar *et al.*, 2003). Table 2 synthesizes, according to several authors, some of the most commonly referenced tools.

Some authors aggregate Lean tools and practices into four buldles: JIT, TPM, TQM and HRM (Bonavia & Marin, 2006; Shah & Ward, 2003). Other authors consider only three of these bundles (Furlan *et al.*, 2011; Cua *et al.*, 2001).

According to the JIT method, an organisation should produce the right quantity of the right item at the right time (Womack & Jones, 1996). Shah & Ward (2003) state that a JIT bundle includes practices whose aim is reducing and eventually eliminating all types of waste, for instance, waste of inventory and/or waste of waiting. These may be lot size reduction, set up time reduction/SMED, cellular manufacturing, among others.

Lean practice	Authors/Sources									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
JIT/continuous flow production	*	*	*	*	*	*	*	*	*	*
Production levelling/ *Heijunka*		*	*	*	*	*	*	*	*	*
Cellular manufacturing	*	*	*	*	*	*	*	*	*	*
Lot size reduction	*		*		*		*		*	*
Pull system/ *Kanban*	*	*	*	*	*	*	*	*	*	*
Work standardization					*	*	*	*		*
Set up time reduction/SMED (Single minute exchange)	*	*	*	*	*	*	*	*	*	*
Mistake proofing/ *Poka-yoke*	*			*	*		*	*	*	*
Total quality management (TQM)	*	*	*	*	*	*	(a)	*	*	
Continuous improvement/ *Kaizen*	*	*	*	*	*		*	*	*	*
Total productive maintenance (TPM)	*	*	*	*	*	*	*	*	*	
5S/housekeeping				*	*	*	*	*	*	
Multi-functional employees/cross training	*	*	*			*	*	*	*	*
Quality circles	*	*	*			*	*			
Value stream mapping (VSM)				*	*		*	*	*	*
Statistical quality control (SQC)	*	*				*	*	*		*

(a) Pettersen (2009) compares Lean manufacturing with TQM, but does not refer to the later as a Lean practice/tool.

(1) Karlsson & Ahlström (1996); (2) White *et al.* (1999); (3) Shah & Ward (2003); (4) Hines *et al.* (2004); (5) Abdulmalek *et al.* (2006); (6) Bonavia & Marin (2006); (7) Pettersen (2009); (8) Eswaramoorthi *et al.* (2011); (9) Belekoukias *et al.* (2014); (10) Sundar *et al.,* (2014)

Table 2 – Lean Tools according to several authors

TPM program consists of establishing a routine of predictive, preventive and corrective maintenance, and replacement programs. This implies the participation of the machine operator in minor machine maintenance (White *et al.*, 1999). The TPM bundle comprises practices such as safety improvement programs (Shah & Ward, 2003).

TQM is a management philosophy that targets customer satisfaction through high quality by capitalizing on the involvement of management, workforce, suppliers, and customers (Abdulmalek *et al.*, 2006; Cua *et al.*, 2001). It includes practices such as continuous improvement/*Kaizen* (Shah & Ward, 2003), or statistical process control (Bonavia & Marin 2006; White *et al.*, 1999).

Finally, HRM is based on employees involvement and commitment (de Treville and Antonakis, 2006 as cited by Furlan *et al.*, 2011). It includes practices such as multi-functional employees/cross training and quality circles (Bonavia & Marin, 2006).

2.5. Some studies on Lean implementation in companies in several countries

There have been several surveys on Lean implementation conducted in different countries. Jasti & Kodali (2014) made a literature review of empirical research methodology in Lean manufacturing where 178 articles published between 1990 and 2009 were analysed and the authors observed that the USA, UK and Spain accounted for 65% of the articles as countries of sample data collection. Among the developing countries India stood out as the one from where more data was collected.

Deepening the analysis of the studies on Lean implementation in companies in various countries, we can conclude that, although they all are about implementation of Lean, the focus of the study is different among them. Table 3 systematizes the main conclusions and classifies the studies in terms its target.

Study Focus	Main Conclusions	Authors/Sources
Degree of Lean implementation	Wider adoption in internal operations than in external relationships	Panizzolo, 1998 (Italy)
	Fragmented implementation	Godinho Filho *et al.*, 2016 (Brasil)
	Infant age	Eswaramoorthi *et al.*, 2011 (India)
	In-transition	Nordin *et al.*, 2010 (Malaysia)
Contextual variable (plant size)	Higher likelihood of implementation of most Lean practices by larger manufacturers than small manufacturers	Bonavia & Marin, 2006 (Spain) Shah & Ward, 2003 (USA) White *et al.*, 1999 (USA)
	Critical factors for a successful Lean implementation in SMEs: leadership, management, finance organisational culture and skills and expertise.	Achanga *et al.*, 2006 (UK)
Impact on operational performance	Positive impact	Godinho Filho *et al.*, 2016 (Brasil) Shah & Ward, 2003 (USA) Staudacher & Tantardini, 2007 (Italy) White *et al.*, 1999 (USA)
	No impact	Bonavia & Marin, 2006 (Spain)
Comparison between countries	Portuguese companies are implementing a smaller number of Lean techniques when compared with the other countries analysed	Silva *et al.*, 2010 (Portugal, UK, USA and Italy)

Table 3 – Classification of some similar studies and main conclusions

In Italy, Panizzolo (1998) interviewed 27 Italian firms operating in international markets to analyse the extent Lean Production model was being adopted and they concluded that the most widely adopted programmes were on the internal operations whilst in the external relationships (supplier and customer) revealed to be more difficult. Also in Italy, Staudacher & Tantardini (2007) questioned both Lean and non-Lean implementers on the strategic objectives, the main barriers, and results over-time and concluded that among the Lean implementers the ones who had implemented for longer, stated much bigger improvements.

The investigation of Godinho Filho *et al.* (2016), conducted in Brazil to research the effect of Lean on the performance encompassed the 10 factors proposed by Shah & Ward (2007). They concluded that Lean was being implemented in a fragmented way and that, even in a fragmented way, it helped improving their operational performance. This notion that Lean has a positive effect on operational performance is supported by others authors such as Shah & Ward (2003) and White *et al.* (1999). However authors like Bonavia & Marin (2006) concluded, in their study to the Spanish ceramic tile industry, that the degree of use of the Lean practices, in most cases, did not have statistically significant influence on operational performance. This, they argue, is probably due to the fact that they studied each practice in isolation rather than as a whole system.

Some studies have shown that in some countries/sectors Lean implementation is still in its infancy: Eswaramoorthi *et al.* (2011) conducted a survey Lean in Indian machine tool manufacturers and they concluded that the sector was still in an infant age of Lean implementation. Similarly, Nordin *et al.* (2010) in their study to Malaysian Automotive Industries found that most of the respondent firms were in-transition towards Lean manufacturing practice.

Various authors have directed their studies to the impact of Lean under contextual variables. For instance, in USA, White *et al.* (1999) made an important contribution to the topic by studying the impact of plant size in Lean implementation. The findings suggest that large U.S. manufacturers are more likely to implement JIT systems than small manufacturers. Shah & Ward (2003) have not only proposed to investigate the impact of plant size but also of plant age and unionization on the implementation of 22 Lean manufacturing practices in a large number of USA companies. This study provided strong support for the notion that plant size influences Lean implementation and that implementation contributes substantially to the operating performance of plants. Another study that investigated Lean's relationship with plant size was conducted in Spain, by

Bonavia & Marin (2006) and, similarly, they found that the contextual variable plant size impacted the degree of use of Lean production practices.

From UK, Achanga *et al.* (2006) studied the critical factors for a successful Lean implementation within SMEs. The research methodology comprised literature review, visits and interviews to 10 SMEs and 3 large enterprises to capture the critical factors. The findings revealed that factors such as leadership, management, finance, organisational culture and skills and expertise are critical.

Specifically in relation to Portugal, Silva *et al.* (2010) studied Lean production implementation in Portuguese companies and compared the results with companies from Italy, UK and USA. Similarly to Staudacher & Tantardini (2007) both Lean implementers and non-Lean implementers were questioned. Lean

Table 4, depicted in the section of methodology, contains more detail about the methodological aspects of those similar studies.

2.6. Measures of Lean Performance

Authors such as, Godinho Filho *et al.* (2016), Shah & Ward (2003) and White *et al.* (1999) have proposed to study the impact of Lean bundles and practices on operational performance. They cited improved quality, improved productivity, stocks reduction, and both lead and cycle time reduction as the main operational benefits from Lean implementation. Other authors have also studied Lean's relationship with performance, and concluded that, implementing Lean impacts positively operational performance (Alsmadi *et al.*, 2012; Cua *et al.*, 2001; Furlan *et al.*, 2011).

Cua *et al.* (2001) investigated the implementation of practices related to three bundles (JIT, TQM and TPM) and of Human and strategic-oriented practices and their impact on cost efficiency, conform quality, on-time delivery, volume flexibility and weighted performance. The conclusions suggest that simultaneous implementation of TQM, JIT, and TPM resulted in higher performance than implementation of practices and techniques from only one bundle. This last conclusion is in line with Shah & Ward (2003) and Furlan *et al.* (2011) who reinforce that total system performance effect will exceed the sum of performance effects of individual practices.

When addressing Lean's impact on firm performance several authors consider that the latter should be balanced between financial, operational and market measures (Alsmadi *et al.* 2012; Büyüközkan *et al.*, 2015). Table 4 presents some measures as cited by some authors aggregated in three categories proposed by Büyüközkan *et al.* (2015).

Firm performance	Measures	Authors/Sources
Operational performance	Cycle time	Alsmadi *et al.* 2012; Bhasin, 2008; Büyüközkan *et al.*, 2015; Shah and Ward 2003
	Manufacturing costs	
	Labour productivity	
	Quality	Bhasin, 2008; Büyüközkan *et al.*, 2015
	Inventory	
Financial performance	Return on sales (ROS)	Büyüközkan *et al.*, 2015; Hofer *et al.*, 2012
	Profit after interest and tax	Bhasin, 2008
Market performance	Market share	Alsmadi *et al.* 2012; Bhasin, 2008; Büyüközkan *et al.*, 2015
	Sales growth	Büyüközkan *et al.*, 2015

Table 4 – Measures for firm performance

2.7. Measures of Lean Implementation

Measuring Leanness has been the aim of many authors, nonetheless, there is no consensus on how Lean should be measured being that in a company, industry or country. Several authors have proposed to develop methods to measure the degree of Lean activity. Some of them have formulated instruments specifically for manufacturing industry. (Herzog & Tonchia, 2014; Karlsson & Ahlström, 1996; Singh *et al.*, 2010; Susilawati *et al.*, 2015)

Karlsson & Ahlstrom (1996) developed an operationalized model to measure progress made in an effort to become Lean. This includes nine determinants, each of them with associated measurements, which are able to reflect changes towards Lean production. They are: waste elimination, continuous improvement, zero defects, JIT delivery, pull production, multifunctional teams, decentralization, functional integration and vertical information systems. Cezar Lucato *et al.* (2014) have pointed out two critics to this model. First, the authors do not propose a single measure to establish the degree of application of the complete set of measurements and a comparison between two different companies is not possible unless the same set of measurements is used for both.

Despite the limitations, some authors have included Karlsson & Ahlstrom (1996)'s nine principles in their model for evaluating Leanness. Soriano-Meier & Forrester (2002) designed a questionnaire specifically to measure two dependent variables and nine independent related to the adoption of Lean production. One of the dependent variables, degree of Leanness (DOL), corresponded to the mean of the nine principles, each one rated on a seven point scale.

Singh *et al.* (2010) also proposed a DOL measurement method considering five parameters to assess Leanness that were rated by a team of five experts in Lean implementation. The authors also included a fuzzy set theory to remove eventual bias. Through these methods they generated various Leanness indices regarding each parameter and that represent "the true picture of Lean status" (Singh *et al.*, 2010, p. 51) Similarly, Susilawati *et al.* (2015) suggested a method for the measurement of degree of Leanness that included 6 parameters (supplier issues, customer issues, manufacturing and internal business, research and development, learning perspectives and investment priority). These parameters were evaluated by at least two experts, and the vagueness of subjective human judgement on degree of application of Lean was modelled by fuzzy number.

Herzog & Tonchia (2014) tested for reliability and validity a questionnaire in 72 Slovenian companies, containing 59 items grouped in nine Lean issues. From this, 24 "Lean" variables were constructed and tested.

One well-accepted instrument to assess the state of Lean implementation in firms is the 10 factors proposed by Shah & Ward (2007). These authors resorted to a data from a large sample and to a rigorous empirical method to identify a set of 48 items, grouped in 10 constructs that the authors believe will allow researchers to identify the Leanness of firms.

2.7. Research framework and hypothesis

The study purposes to investigate to what extent Lean practices are being implemented in Portuguese manufacturing SMEs, to further determine the studied companies' state regarding Lean implementation. Adapting from Nordin *et al.* (2010), the companies will be then grouped in non-Lean, in transition to Lean, or Lean. Therefore, the following hypotheses are tested in the present study:

H1a: Most Portuguese manufacturing SMEs are Lean.

H1b: Most Portuguese manufacturing SMEs are non-Lean.

H1c: Most Portuguese manufacturing SMEs are in-transition to Lean.

Regarding firm's performance, and bearing in mind the categories suggested by Büyüközkan *et al.* (2015), the paper also purposes to test the following hypothesis:

H2a: Lean manufacturing is positively associated with operational performance.

H2b: Lean manufacturing is positively associated with market performance.

H2c: Lean manufacturing is positively associated with financial performance.

Additionally, this paper aims to compare the results with the perception of the studied companies regarding their Lean position. Hence, the final hypothesis tested in the present study:

H3: Portuguese SMEs have an accurate perception regarding their Lean status

Fig. 1 is a research framework that represents how Portuguese companies are related to Lean manufacturing. And in its turn, how Lean is related with market, operational and financial performance of those Portuguese companies.

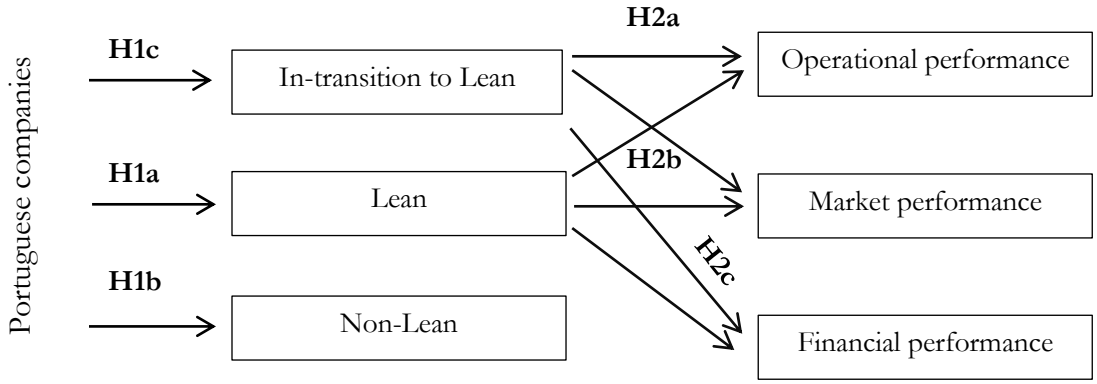

Figure 1 – Research Model

3. Methodology

This section starts with a brief revision about the methodologies employed in similar studies. Then, it is presented the method selected for the research and the definition of each of its steps, the sources of information, the structure of the survey and its measures and scales.

3.1. Methodological aspects of similar studies

Studies on Lean implementation in different countries present different methodological aspects regarding the studied industry, data collection, statistical analysis and sample.

Table 5 presents a synthesis of the methodological aspects of the similar studies made in countries such as Italy, USA, India, among others. From this we can observe that most of studies are conducted in multiple industries rather than focusing exclusively on a sector. Regarding the sample, it can be noted that the studies conducted in USA (Shah & Ward, 2007; White *et al.,* 1999) have the biggest sample size. Additionally, some authors have divided their sample into Lean and Non- Lean implementers (Silva *et al.*, 2010; Staudacher & Tantardini, 2007). The choice of sample firms' size is heterogeneous. Whilst certain authors propose to study all firms' sizes (Eswaramoorthi *et al.,* 2011), others focus only on smaller firms (Godinho Filho *et al.*, 2016) and some solely on larger firms (Nordin *et al.*, 2010).

The methods for collecting data are mostly questionnaires, having only two authors performed interviews (Achanga *et al.*, 2006; Panizzolo, 1998). Also Achanga *et al.* (2006) and Bonavia & Marin (2006) associated their questionnaire or interview with visits to the facilities to obtain data by direct observation. To all of these methods, the respondents are mainly managers, directors or executives. Further, it can be observed that almost all authors conducted some sort of statistical analysis. The most commonly used were descriptive statistics analysis and analysis of variance using ANOVA. Despite not being expressed in Table 5, almost all authors have performed reliability and validity tests for data using Cronbach's α.

Author	Country of study	Industrial Sector	Sample Size	Response rate	Informant	Firm Size	Data collection	Statistical analysis
Achanga *et al.*, (2006)	UK	Multiple industries	10 3	100%	General workforce	SME L	Interview; Participants Obs.	-
Panizzolo (1998)	Italy		27	100%	Managers from various areas	L & SME	Interview	Descriptive statistics; Cluster analysis
Staudacher & Tantardini (2008)			61 LI 51 NLI	3,90%	Not clear	L & ME	Questionnaire	-
Shah & Ward (2003)	USA		1757	6.7%	Plant/ Manufacturing Leaders and Managers;	L & SME		Descriptive statistics; χ^2test; Regression analysis; ANOVA
White *et al.*, (1999)			454	44.1%	Middle to top managers position	L & SE		Descriptive statistics Regression analysis
Godinho Filho *et al.*, (2016)	Brazil		52	2.72%	Mostly Managers and Directors	SME		Descriptive statistics; ANOVA; PLS-SEM
Silva *et al.*, (2010)	Portugal		27 LI 125 NLI(a)	4%	Not clear	L & SME		-
Eswaramoorthi *et al.*, (2011)	India	Machine tool industries	43	29%	Managers and shop floor engineers			Descriptive statistics; Non parametric test
Nordin et al., (2010)	Malaysia	Automotive Industry	61	24.4%.	Production and Quality Managers and Executives	L & ME		ANOVA; Clusters analysis
Bonavia & Marin (2006)	Spain	Ceramic tile industry	76	79.17 %	Senior production managers	L & SME	Questionnaire and Participants Obs.	Non parametric tests; Mantel Haenszel Test

(a) The article does not say specifically how many Non-Lean Implementers. Calculated through response rate.

Table 5 – Methodological considerations of similar studies

3.2. Methodology selection

In order to trace the implementation status of Lean production across Portuguese manufacturing SMEs and its effects on their performance, the methodology chosen has been the questionnaire. This was considered the most adequate method, since targeting a representative sample was compulsory to be able to outcome conclusions regarding Portuguese manufacturing SMEs. To this degree of analysis it would not be feasible to conduct any other methodology. In addition, questionnaire has been the chosen method by several others studies with a purpose similar to this study.

The questionnaire was divided in four parts. Part 1 captures the organization profile and personal information of the respondent. Part 2 captures the level of Leanness of the company. Part 3 assesses the impacts of Lean on performance measures. Finally, part 4 addresses questions regarding company perception of self-Leanness.

3.3. Sample

The sample was created considering Portuguese enterprises registered in SABI. There was the need to place some restrictions in order to come up with a database only with manufacturing SMEs. Firstly, the manufacturing sector selection was made according to NACE Rev. 2 classification, and therefore, only enterprises coded 10 to 32 were considered. Then, concerning firms' size, the criteria used was bearing in mind the definition of SMEs by European Commission: "The category of micro, small and medium-sized enterprises (SMEs) is made up of enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million" (Official Journal of the European Union).

Hence, there were only considered companies with less than 250 employees and with an annual turnover lower than 50 million. Furthermore, a minimum annual turnover of 100 thousand was established. This additional restriction was imposed because financial capability is a critical success factor for Lean implementation, meaning that, financial inadequacy is a major barrier to Lean implementation or success (Achanga *et al.*, 2006). Therefore, it is expected that companies with very low annual turnover won't have the will to implement Lean, neither ability to reach success if they try to implement it.

After this a database with 10 390 companies was organized including companies' operating revenue, sales, number of employees, e-mails of approximately 7 800 companies and telephone contact.

3.4. Measures definition

In order to assess companies' degree of Lean implementation it was used the instrument proposed by Shah & Ward (2007) . This includes 10 factors (constructs) to represent Lean production. Of these 10 constructs, one of them measures customer involvement, three measure supplier involvement and six measure internal issues. To each of the 10 constructs is associated at least 3 items that make up a total of 48 items. To every item the company is expected to express their level of implementation according to a 5 point Likert scale being 1 (no implementation) and 5 (complete implementation). These 10 factors are discriminated in Table 6:

	Underlying constructs	**Operational factors**
Lean Production	Supplier involvement	Supplier feedback
		JIT delivery
		Developing suppliers
	Customer involvement	Involved customers
	Internal	Pull production
		Continuous flow
		Setup time reduction
		Statistical process control
		Total productive maintenance
		Involved employees

Table 6 – Factors for measuring Lean production

(Adapted from Shah & Ward, 2007)

However, this instrument was developed considering solely companies with more than 100 employees. This condition can be considered a limitation since the present study proposes to focus only on SMEs.

In its turn, Lean's impact on performance is determined by market, financial and operational measures as proposed by authors such as Alsmadi *et al.* 2012 and Büyüközkan *et al.* 2015. In this study, cycle time, manufacturing costs, labour productivity, quality and inventory are grouped as operational measures; return on sales (ROS) and profit after interest and tax as financial measures; market share and sales growth as market measures.

4. Chronogram of activities

This brief section includes the planning and scheduling of the activities of this dissertation, for the next 6 months.

The remaining days of this month will be dedicated to finishing elaborating the questionnaire to be sent in the beginning of February. Meanwhile data is being collected the statistical analysis that will be used in order to test the hypothesis will be clarified (Structural Equation Modelling, Regression Analysis, Cluster Analysis...). After having the responses the data will be analysed and processed and April will be dedicated to elaborate the results discussion and conclusion.

TASKS	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
Completing questionnaire's elaboration/ Measures definition						
Sending online questionnaire to firms from database						
Clarify statistical analysis to be used						
Analysing and Processing the data						
Elaboration of the discussions and conclusions						
Delivery to the supervisor for review						
Delivery of the dissertation						

References

Abdulmalek, F. A., Rajgopal, J., & Needy, K. L. (2006). A classification scheme for the process industry to guide the implementation of lean. *Engineering Management Journal, 18*(2), 15-25.

Achanga, P., Shebab, E., Roy, R., & Nelder, G. (2006). Critical Sucess factors for lean implementation within SMEs. *Journal of Manufacturing Technology Management, 17*(4), 460-471.

Alsmadi, M., Almani, A., & Jerisat, R. (2012). A comparative analysis of Lean practices and performance in the UK manufacturing and service sector firms. *Total Quality Management & Business Excellence, 23*(3-4), 381-396.

Belekoukias, I., Garza-Reyes, J. A., & Kumar, V. (2014). The impact of lean methods and tools on the operational performance of manufacturing organisations. *International Journal of Production Research, 52*(18), 5346-5366.

Bhamu, J., & Singh Sangwan, K. (2014). Lean manufacturing: literature review and research issues. *International Journal of Operations & Production Management, 34*(7), 876-940.

Bhasin, S. (2008). Lean and performance measurement. *Journal of Manufacturing Technology Management, 19*(5), 670-684.

Bonavia, T., & Marin, J. A. (2006). An empirical study of lean production in the ceramic tile industry in Spain. *International Journal of Operations & Production Management, 26*(5), 505-531.

Büyüközkan, G., Kayakutlu, G., & Karakadılar, İ. S. (2015). Assessment of lean manufacturing effect on business performance using Bayesian Belief Networks. *Expert Systems with Applications, 42*(19), 6539-6551.

Cezar Lucato, W., Araujo Calarge, F., Loureiro Junior, M., & Damasceno Calado, R. (2014). Performance evaluation of lean manufacturing implementation in Brazil. *International Journal of Productivity and Performance Management, 63*(5), 529-549.

Comm, C. L., & Mathaisel, D. F. (2000). A paradigm for benchmarking lean initiatives for quality improvement. *Benchmarking: An International Journal, 7*(2), 118-128.

Cua, K. O., McKone, K. E., & Schroeder, R. G. (2001). Relationships between implementation of TQM, JIT, and TPM and manufacturing performance. *Journal of Operations Management, 19*(6), 675-694.

Dennis, P. (2016). *Lean Production simplified: A plain-language guide to the world's most powerful production system.* Crc press.

Eswaramoorthi, M., Kathiresan, G. R., Prasad, P. S., & Mohanram, P. V. (2011). A survey on lean practices in Indian machine tools industries. *The International Journal of Advanced Manufacturing Technology, 52*(9-12), 1091-1101.

Furlan, A., Vinelli, A., & Dal Pont, G. (2011). Complementarity and lean manufacturing bundles: an empirical analysis. *International Journal of Operations & Production Management, 31*(8), 835-850.

Gelei, A., Losonci, D., & Matyusz, Z. (2015). Lean production and leadership attributes–the case of Hungarian production managers. *Journal of Manufacturing Technology Management, 26*(4), 477-500.

Godinho Filho, M., Ganga, G. M., & Gunasekaran, A. (2016). Lean manufacturing in Brazilian small and medium enterprises: implementation and effect on performance. *International Journal of Production Research, 54*(24), 7523-7545.

Herzog, N. V., & Tonchia, S. (2014). An instrument for measuring the degree of lean implementation in manufacturing. *Strojniški vestnik-Journal of Mechanical Engineering, 60*(12), 797-803.

Hines, P., Holweg, M., & Rich, N. (2004). Learning to evolve: a review of contemporary lean thinking. *International journal of Operations & Production Management, 24*(10), 994-1011.

Hofer, C., Eroglu, C., & Hofer, A. R. (2012). The effect of lean production on financial performance: The mediating role of inventory leanness. *International Journal of Production Economics, 138*(2), 242-253.

Holweg, M. (2007). The genealogy of lean production. *Journal of Operations Management, 25*(2), 420-437.

Jasti, N. V., & Kodali, R. (2014). A literature review of empirical research methodology in lean manufacturing. *International Journal of Operations & Production Management, 34*(8), 1080-1122.

Jasti, N. V., & Kodali, R. (2015). Lean production: literature review and trends. *International Journal of Production Research, 53*(3), 867-885.

Karlsson, C., & Ahlström, P. (1996). Assessing changes towards lean production. *International Journal of Operations & Production Management*, 24-41.

Ndaita, P. M., Gachie, T., & Kiveu, C. W. (2015). The implementation of Lean Six Sigma concept at national bank of Kenya-operation division. *The TQM Journal, 27*(6), 683-690.

Nordin, N., Deros, B. M., & Wahab, D. A. (2010). A survey on lean manufacturing implementation in Malaysian automotive industry. *International Journal of Innovation, Management and Technology, 1*(4), 374.

Ohno, T. (1988). *Toyota Production System: beyond large-scale production.* crc Press.

Panizzolo, R. (1998). Applying the lessons learned from 27 lean manufacturers: The relevance of relationships management. *International Journal of Production Economics, 55*(3), 223-240.

Pavnaskar, S. J., Gershenson, J. K., & Jambekar, A. B. (2003). Classification scheme for lean manufacturing tools. *International Journal of Production Research, 41*(13), 3075-3090.

Pettersen, J. (2009). Defining lean production: some conceptual and practical issues. *The TQM Journal, 21*(2), 127-142.

Shah, R., & Ward, P. T. (2003). Lean manufacturing: context, practice bundles, and performance. *Journal of operations management, 21*(2), 129-149.

Shah, R., & Ward, P. T. (2007). Defining and Developing measures of lean production. *Journal of Operations Management, 25*(4), 785-805.

Silva, C., Tantardini, M., Staudacher, A. P., & Salviano, K. (2010). Lean Production Implementation: A survey in Portugal and a comparison of results with Italian, UK and USA companies. *17th International Annual EurOMA Conference–Managing Operations in Service Economics, R. Sousa, C. Portela, SS Pinto, and H. Correia, eds.*

Singh, B., Garg, S. K., & Sharma, S. K. (2010). Development of index for measuring leanness: study of an Indian auto component industry. *Measuring Business Excellence, 14*(2), 46-53.

Soriano-Meier, H., & Forrester, P. L. (2002). A model for evaluating the degree of leanness of manufacturing firms. *Integrated Manufacturing Systems, 13*(2), 104-109.

Staudacher, A. P., & Tantardini, M. (2007). Lean Production implementation: a survey in Italy. *XI Congreso de Ingeniería de Organización*, 1269-1279.

Sundar, R., Balaji, A. N., & Kumar, R. S. (2014). A review on lean manufacturing implementation techniques. *Procedia Engineering, 97*, 1875-1885.

Susilawati, A., Tan, J., Bell, D., & Sarwar, M. (2015). Fuzzy logic based method to measure degree of lean activity in manufacturing industry. *Journal of Manufacturing Systems, 34*, 1-11.

Wahab, A. N., Mukhtar, M., & Sulaiman, R. (2013). A conceptual model of lean manufacturing dimensions. *Procedia Technology, 11*, 1292-1298.

White, R. E., Pearson, J. N., & Wilson, J. R. (1999). JIT manufacturing: A survey of implementations in small and large U.S. manufacturers. *Management Science, 45*(1), 1-15.

Womack, J. P., & Jones, D. T. (1996). *Lean thinking: Banish waste and create wealth in your corporations* (1st ed.). Simon & Shuster, Inc., The Free Press, New York.

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The machine that changed the world* (1st ed.). Simon & Schuster, Inc., The Free Press, New York.

Wong, Y. C., & Wong, K. Y. (2011). A lean manufacturing framework for the Malaysian electrical and electronics industry. *In Proceedings of the 3rd International Conference on Information and Financial Engineering, 12*, 30-34.

http://www.pordata.pt/en/Portugal/Enterprises%27+gross+value+added+total+and+by+size-2916-246650

www.pordata.pt/en/Portugal/Small+and+medium+sized+enterprises+as+a+percentage+of+total+enterprises+total+and+by+size-2859

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