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"ECONOMIC AND FINANCIAL RETURNS OF LEAN OVER TIME: EMPIRICAL EVIDENCE FROM ITALIAN MANUFACTURING FIRMS"

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Ilenia Boschetto

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INTRODUCTION

The current business scenario – characterized by tough competition – has alerted many manufacturing firms to undertake programs aimed to waste minimization and cost reduction. Moreover, companies must adjust their production to timely fulfill the customer requests and to effectively face changes in the demand. In this framework the manufacturing industry broadly discusses about the Lean philosophy but, how many companies actually know what is it about and how many companies are really involved in its implementation? Ever since its introduction, the concept of Lean thinking has gained widespread consideration, both in literature and in practice, so that nowadays it is part of many manufacturing strategies. Its enforcement in the production field has become – probably – the dominant strategy for organizing the production systems, an evidence which confirms the expectations of Womack et al. (1990, p.278) when they state that "[Lean production] will supplant both mass production and the remaining outposts of craft production in all areas of industrial endeavor to become the standard global production system of the 21st century".

The rationale behind Lean implementation relies on the possibility to positively affect the growth rate, a crucial element for companies' survival being that "the result by which any business in a market economy must be measured is the ability to make enough profit to renew itself" (Womack and Jones, 1996, p.121). Nevertheless, not always Lean implementation brings to the expected benefits so that some companies still choose to not embrace this philosophy as part of their manufacturing and managerial processes. This choice could be partially explained by the uncertain results of Lean in the business context, so that companies might fear that the cost related to Lean implementation may outweigh the potential benefits entailed.

This paper is part of the research field that tries to understand whether Lean positively affects the business performance (*Hypothesis 1*). Narrowing the scope, the research purpose is testing whether and how the leanness intensity (*Hypothesis 2*) – intended as how extensively Lean practices are concurrently implemented within the company – and especially the leanness maturity (*Hypothesis 3*) – intended as the timespan of experience with Lean applications – have a positive impact on the company's economic and financial performance. Nevertheless, the

main contribution of this paper is given mixing together Hypotheses 2 and 3, with the purpose to test the financial behavior of different subsets of companies which differentiate among them for their leanness intensity and maturity (*Hypothesis 4*). The business performance will be measured through the return on equity, and then compared to the results over the return on assets and EBITDA-to-sales to verify the robustness of the analysis.

The organization of this paper is as follows.

Chapter 1 provides an overview about the importance of incorporating the Lean concepts in the manufacturing industry, even if numerous challenges hinder the effective path to attain it. For this reason, it is preliminary having knowledge about the five Lean principles which constitute the milestone for undertaking a Lean transformation and which explain how the company can improve any production endeavor. As already anticipated, worldwide companies strive to achieve Lean manufacturing even if not all of them are successful in its perfect implementation and complete exploitation of its benefits, a result which is affected also by the application of the right tools and techniques which allow waste identification and elimination.

Lean is gaining popularity as an approach that can potentially improve significantly the performance in the industry. The uncertainty is not about the operating benefits entailed by Lean but, rather, the economic and financial ones so that *Chapter 2* opens carrying out a detailed literature review on this topic. Despite the mixed results reached in such field, this paper has been developed to investigate two specific aspects of Lean: the leanness intensity and the leanness maturity. The chapter explores extant theory and suggests that striving to achieve a wider, deeper, comprehensive and more advanced Lean implementation level generally leads companies to experience higher benefits. However, for the purpose of this research, it is even more important to clarify that Lean consists of a series of continuous transformations which gradually alter the whole structure of the company. Using the words of Byrne (2016), “you can't just add lean on top of a traditional structure and expect success”. This introduces the concept of time, which will be used to assess the success of Lean companies and thus considering the maturity as parameter.

To be able to perform the analysis which will answer the research questions, a survey comprehensive of 35 questions on Lean management has been sent to Italian manufacturing firms, and a sample of 454 companies has been collected. Consequently, *Chapter 3* aims to present the sample which – later – will be used for the empirical analysis. A funnel approach has been adopted to design the structure of this chapter, meaning that as the descriptive analysis moves on, an increasingly higher level of specificity has been achieved. In other terms, after having presented the characteristics of the whole sample, it has been divided in two groups to

capture the differences between firms which are Lean and the ones which are not Lean. After that, for the most important attributes highlighted during the previous elaborations, a further distinction of Lean companies has been made in order to find whether some differences result among companies with different intensities and different maturities of Lean implementation. Finally, a detailed discussion about the economic and financial performance has not been neglected.

Data presented in Chapter 3 have been used to perform a fine-grained analysis in *Chapter 4*. After a detailed explanation of the dependent, independent and control variables included in the models, it presents the methodology used for testing the research hypotheses and reports the statistical analysis carried out. The research has been drafted with the purpose of providing a general viewpoint over the matter, which will become the input to develop ad hoc answers for the most uncertain results. Indeed, through some OLS regressions, this paper wants to investigate whether the intensity and the length of Lean adoption affect the linkage between Lean production and business performance.

This paper ends with *Chapter 5* which discusses in a critical way the results reached through the empirical analyses performed in Chapter 4. It is possible to anticipate that the findings suggest how being a company which extensively adopt Lean practices within the organizational context positively and significantly impacts the financial performance whereas the length with which the company experiences Lean does not affect the performance. Finally, the chapter identifies the strengths and limitations of this study, also providing some future research opportunities.

CHAPTER 1: THE LEAN THINKING FOUNDATIONS

1.1 The Lean Thinking philosophy

Customer needs change over time and consequently the production techniques in which companies rely on require to be redesigned. In the high-volume and low-variety context which characterized the first part of the XX century, the mass production was, for sure, the most suitable manufacturing system because it put emphasis on efficiency, but in the second half of the same century the customer interests and preferences changed, moving towards a low-volume and high-variety context. In this framework, the mass production was no longer the best choice, indeed a standardized production system did not fit anymore with the customer demand and needs. On one side, the greater global competition – which led companies to focus on process flexibility, higher product quality and increased innovation speed – and, on the other one, the financial distress caused in particular by the World War II, required to look for new methods of performing the production process aimed at facing the changed market scenario (Bhamu and Singh Sangwan, 2014). These are the reasons why Toyota – a Japanese automobile company – started to think about "an entirely new way of making things" (Womack et al., 1990) using very low inventory and moving decision-making to production workers: initially recognized as *Toyota Production System* (TPS), it allowed the company to achieve superior results relative to competitors and consequently in the '90s it spread in the Western manufacturing as *Lean production*. The term "Lean" became popular in 1990 thanks to the book "*The machine that changed the world*" by Womack, Jones and Roos in which they compared the production systems of the main US and European automobile manufacturers with the Japanese Toyota, revealing the clear superiority of the latter compared to all the others in terms of productivity, quality and other measures of manufacturing performance. Womack, Jones and Roos (1990, p.13) provided the first definition of what Lean means highlighting that "Lean production is *lean* because it uses less of everything compared with mass production – half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also, it requires keeping far less than half the inventory on site, results in many fewer defects, and produces a greater

and ever growing variety of products". The fundamental contribution of the authors continues to represent a guide for companies in every industry seeking to transform the traditional production system into exemplars of Lean success.

In this scenario, a short introduction about Toyota cannot be neglected. Toyota's origins date back to 1926 when Sakichi Toyoda created the *Toyoda Automatic Loom* for the textile production. The peculiarity was its automatic nature which made possible to detect a snapped thread – or any other type of problem – and consequently the loom automatically stopped. This introduction revolutionized the way in which the production was performed for several reasons (Womack et al., 1990):

- it prevented problems to continue: if the machine automatically stops when there is a problem, the operator can search for the root cause of the problem, troubleshoot it and restart the production only when it has been solved, thus preventing production of poor quality. This is completely in line with the Lean logic according to which problems should be exposed as soon as they arise, so that they can be corrected immediately;
- it did not require a full-time operator involved in supervising each loom: by incorporating a device which automatically stops the loom from operating whenever a problem appears, this enables great improvements in quality and allows operators to do more value creating work than simply supervising machines for quality;
- it prevented the company from overproducing: if the machine automatically stops when the daily number of items has been achieved, it is possible to avoid overproduction – which is one of the most important wasteful activity.

Eventually, this simple concept found its way into every machine, every production line and every operation, thus representing the starting point for the consolidation of the Toyota Production System – whose creator is considered Taiichi Ohno, the managing director of Toyota. Some years later, in 1936, Kiichiro Toyoda – Sakichi Toyoda's son – decided to diversify into the automobile manufacturing founding the *Toyota Motor Corporation*, and he soon realized the need to "catch up with America in three years. Otherwise, the automobile industry of Japan will not survive" (Ohno, 1988). This laid the groundwork for the growth of the Toyota Group and for the Lean's spread in the manufacturing field.

In production, the Lean purpose is about using less inputs to create the same output while contributing increased variety for the final customer (Womack and Jones, 1996). More specifically, as Shah and Ward (2003) stated, Lean manufacturing can be best defined as an approach to deliver the upmost value to the customer by continuously minimizing waste

throughout a product's entire value stream making use of process and human design elements. In other words, the milestone of such paradigm refers to the involvement of people stimulated to continuous improvement. Nevertheless, the Lean concept can be described in a broader perspective as a dynamic process of change driven by a systematic set of principles and best practices aimed at continually improving the manufacturing processes, as well as the administration, management and supply chain (Womack et al., 1990). Indeed, what is important to stress is that companies are trying to expand the scope of the Lean philosophy outside the strict manufacturing field, witnessed for instance by Cusumano et al. (1998) in their book *Thinking Beyond Lean* in which they argue the Lean implementation to product development process. Thus, based initially on Toyota's business system, the Lean logic has been now extended to the entire Lean management system.

1.1.1. The role of wastes and their identification through the Gemba Walk

To effectively achieve the Lean purpose, it is necessary to reduce all the wastes – in Japanese, *Muda* – that inevitably affect every production stage (Tapping, 2002). Being more specific, Lean thinking's introduction within the manufacturing environment requires dedicated tools and techniques, which can be effectively selected only after waste identification and elimination (Hicks, 2007).

"[…] all elements of production that only increase cost without adding value – for example, excess people, inventory, and equipment" – and consequently for which customers are not willing to pay for, is how Ohno (1988) defined the concept of waste in the Lean context. In other terms, once that what value is and what activities and resources are necessary to create that value have been understood, everything else is waste. Being waste identification the preliminary step toward the TPS application, Taiichi Ohno (1988) detected the following seven types of waste:

- waste of overproduction, which refers to process transformation of products not needed;
- waste of time-on-hand, which refers to any delay in the actions that accomplish process transformation;
- waste in transportation, which refers to any unnecessary movement of material or products;
- waste of processing itself, which refers to the unneeded steps to process the parts;

- waste of stock-on-hand, which refers to the inventory of work-in-process and finished goods;
- waste of movement, which refers to any motion which does not transform the product adding value;
- waste of making defective products.

Clearly identifying the wastes and acting on key points, companies may capture the first benefits and then going on in order to achieve their expectations for what concerns an alignment toward the Lean world. This is the reason why in approaching a Lean strategy, companies first of all should perform the *Gemba*[1] *Walk*: this is a management practice of regularly going to the workplace. It confirms the insight according to which "the best way to get a meaningful understanding of a problem is personally going to the place where action is taking place to observe the situation"[2] (Emuze and Saurin, 2015). Taking managers in front of the production line is not only a way to see the actual practices and detect the related wasteful activities, but also to engage with employees building a relationship based on mutual trust, gain knowledge about the manufacturing process and explore opportunities for continuous improvement (Castle and Harvey, 2009).

The Gemba Walk allows to understand from the very beginning what the three keys to Lean leadership are (Shook, 2011):

1. go and see: senior management must spend time on the front lines;
2. ask why: managers should explore the value stream in detail and detect issues through active communication;
3. show respect: "respect your people", a Lean leading principle which will be broadly discussed later on.

Dealing with wastes is fundamental because the Lean logic develops around them, which in turn will affect all the other organizational aspects.

1.1.2. What being a Lean company means

The way in which companies approach to Lean depends on the awareness of what being Lean means, and this determines the success or the failure of the whole system. Often, companies

[1] *Gemba* – or *Genba* – is a Japanese term which stands for "the actual place", so it refers to the place where value is created.
[2] This concept refers to the *Genchi genbutsu* principle, which means "Go and see for yourself".

adopt the wrong approach from the very beginning as they primarily look for dedicated Lean techniques aimed at cost reduction, neglecting that this is not a strategy directly intended to pursue this goal. Therefore, knowing the real implications in practical terms is a crucial element to be considered in following an initiative of such scope.

After having understood the role of wastes, the following phase consists in having a clear idea of the two leading principles of Lean which can be summarized in *continuous improvement* and *respect for people* (Toyota Motor Corporation, 2001).

Taiichi Ohno (1988) stated that "the most important objective of the Toyota System has been to increase production efficiency by consistently and thoroughly eliminating waste": this is what Toyota means with "*Continuous improvement*". For materialization of this culture, everyone should work together to make incremental advancements without necessarily making huge capital investments, meaning that Lean implementation does not require breakthrough improvements but small steps of improvements every day, to everyone and everywhere instead (Bhuiyan and Baghel, 2005). In other terms, this logic is based on the assumption that there is always room for improvements in quality cost, delivery and design. To coordinate the continuous improvement efforts, the PDCA-cycle of Edwards Deming can be used: it empathizes that improvement programs should follow the sequence Plan, Do, Check and Act[3], at whose completion the following cycle should start immediately to deal with another problem (Soković et al., 2009). This represents one of the main tools used by Lean companies to face process advancement and achieve the excellence.

The second principle of Lean is "*Respect for people*" which, from the Toyota viewpoint, consists of two parts: *Respect* and *Teamwork* (Toyota Motor Corporation, 2001).

On one side, *Respect* means: "We respect others, make every effort to understand each other, take responsibility and do our best to build mutual trust" (Toyota Motor Corporation, 2001). A Lean company should respect the intrinsic value of people, a concept that Ohno (1988) tried to explain in the following way: "The management's responsibility is to identify excess manpower and utilize it effectively. Hiring people when business is good and production is high just to lay them off or recruiting early retirees when recession hits are bad practices. Managers should use them with care". Since Lean allows to find waste and reduce cost, the company requires for sure less people, but they should not be fired. Most of the firms do Lean just because this is the current trend, just because it can result in a 50 percent reduction of human effort, manufacturing

[3] The *Plan* phase consists in analyzing what needs to be improved, by taking into consideration areas that hold opportunities for change. The *Do* phase consists in the implementation of the countermeasures, one at a time. The *Check* phase consists in controlling if the countermeasure works. The *Act* phase consists in keeping improvement ongoing, thus standardizing the countermeasure.

space, tool investment and product development time, while neglecting its real nature as growth strategy (Zayko et al., 1997). Indeed, the idea behind Lean is to reinvest the resources saved with the purpose of growing the firm. Here the role of the Kaizen Promotion Office – KPO, also called Lean Office or Continuous Improvement Office – became important: a KPO is an office filled with people from whatever area of the company – from management to process engineering and workstation – which does improvement activities on a full-time basis. This means that additional people not needed anymore in the production process after having implemented a Lean strategy, can be engaged in the KPO rather than being fired.

On the other side, *Teamwork* means: "We stimulate personal and professional growth, share the opportunities of development and maximize individual and team performance" (Toyota Motor Corporation, 2001). In this perspective, the Lean system's distinctive feature refers to the ability of workers "to display in full their capabilities through active participation in running and improving their own workshops" (Sugimori et al., 1977), emphasizing the supporting role of managers instead of a mere role of giving orders (Poppendieck, 2011). In other words, Lean needs to make people proactive, so that Ohno transferred most of the work done by engineers and managers in mass production facilities to workers: what may seem to be a failure has instead allowed success since the line started to run with very few problems, because the assembly workers felt responsible to find, expose and solve problems as they occurred. Consequently, the Lean company becomes an organizational environment characterized by the awareness that the workstation is the place where everyone can learn from one another and grow as individual, rather than just a place to work (Emiliani, 2008).

1.2. The Lean Thinking principles

The overview of concepts underlying this philosophy is preliminary for understanding the principles upon which Lean is based. Indeed, the initial concept of Lean has been deepened in 1996 by five key principles expressed in the Womack and Jones model: they constitute the milestone for undertaking a Lean transformation and they explain how the company can improve any production endeavor. Nevertheless, Lean principles are not the result of theoretical constructs by scholars, but they are notions first developed in practical terms and later formulated by academics according to the findings.

Womack and Jones (1996) state that a Lean way of thinking allows companies to "specify value, line up value-creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively".

The five Lean thinking principles which result are: specify value, identify the value stream, flow, pull and pursue perfection.

1.2.1. Specify value

The first essential element that Lean must incorporate is *Value*, a critical construct because producers may have one definition in contrast with the one of customers. Value has been defined by Womack and Jones (1996, p.311) as the "capability provided to customer at the right time at an appropriate price, as defined in each case by the customer", meaning that a Lean company should offer products which satisfy the customer needs in terms of price and time. Accordingly, what sets Lean apart is its customer-focused nature which defines the business orientation, moving from the assumption that the organizational efforts should be addressed to meet what customers value the most. This represents a challenge for a company which approaches to Lean for the first time because of the traditional tendency of both producers and customers targeted toward lower costs, customization and instant delivery (Womack and Jones, 1996).

Essentially three implications follow this new Value's outlook. *Firstly*, it is necessary to define what the resources and activities that contribute to value creation are, while all the other elements are wastes. Nevertheless, this is not enough. Indeed, the company should strictly follow the "do it right the first time" logic taking care that the product quality and features fit with customer expectations (Poppendieck, 2011). *Secondly*, by elevating the customer role, the company should adopt a product focus. This entails the need to rely on products teams involved in extracting the value definitions aimed at reaching a consensus in the producer-customer relationship (Womack and Jones, 1996). *Thirdly*, this new way of approaching to production impacts on how price is defined: instead of considering the market trend, the price of Lean products should take into account the target cost for development considering the ideal situation of waste minimization. Producing without Muda means for sure lower costs. The resulting gap between market price and cost sustained by the company – increased of the mark-up that it wants to gain – can be exploited in different ways, ranging from price reduction, to enhanced quality, additional services and R&D investments (Womack and Jones, 1996).

1.2.2. Identify the value stream

The *value stream* is a set of "specific activities required to design, order, and provide a specific product, from concept to launch, order to delivery, and raw materials into the hands of the

customer" (Womack and Jones, 1996, p.311). These activities can be sorted in three categories: (1) activities that actually create value as perceived by the customer; (2) activities that create no value but are currently required given the context in which the company operates; (3) activities that do not create value as perceived by the customer. Once the third type of wasteful activities has been removed to the maximum possible extent, it is possible to map the process that creates value within the company, giving representation of every process in the material and information flows (Rother and Shook, 2003).

1.2.3. Flow

A well-defined value stream allows to make value *flow* continuously. This principle has been clearly summarized by Womack and Jones (1996, p.306) as the "progressive achievement of tasks along the value stream so that a product proceeds from design to launch, order to delivery and raw materials into the hands of the customer with no stoppages, scrap or backflows".

Lean production is designed to maintain a continuous flow of products in order to flexibly adjust to demand variability. This is the idea behind the Just-in-Time logic: applying techniques designed to minimize scrap and inventory – or broadly, all forms of waste –, the company experiences higher quality and productivity, and lower costs (Bhuiyan and Baghel, 2005). The primary challenge is to break the batch-and-queue habit of mass production and to encourage a one-piece-flow production, which can be "best achieved by eliminating traditional functional organizations and replacing them with integrated product teams organized along the value stream" (Murman et al., 2002).

1.2.4. Pull

The idea that flow should be "*pulled*" from demand is fundamental in Lean production. Womack and Jones (1996, p.309) point out that in a pull system "nothing is produced by the upstream supplier until the downstream customer signals a need". Indeed, in a Lean world the production is subordinated upon the arrival of customer demand, thus activating the operations only for what it is needed and only when it is needed. This system works by means of *Kanban*, a system which uses cards for signaling to the preceding process that more parts are needed (Slack et al., 2013, p.465). Thus, think at the production process from downstream to upstream is the way in which – in a Lean context – companies cope with inventory minimization. The effect of a pull system of control is that production does not anymore occur according to the

forecasts, instead the commitment of companies is delayed until the actual demand – for being sure that the organizational efforts are addressed toward something that customers really want.

1.2.5. Pursue perfection

Pursue *perfection* refers to the "complete elimination of Muda so that all activities along a value stream create value" (Womack and Jones, 1996, p.308). However, completely remove waste is more a desired end-state than a truly achievable goal because – for instance – the complete elimination of the stock-on-hand waste leads to time-on-hand waste. Consequently, in the real world, perfection means that the company is involved in continuous improvement – in Japanese, *Kaizen*. In other terms, the achievement of perfection requires constantly considering what is being done and how it is being done, and harnessing the expertise and knowledge of all those involved in the processes to improve and change them (Garnett et al., 1998). Moving from the assumption that Lean objectives are ideals, in this perspective Lean firms should strive for getting closer to them over time.

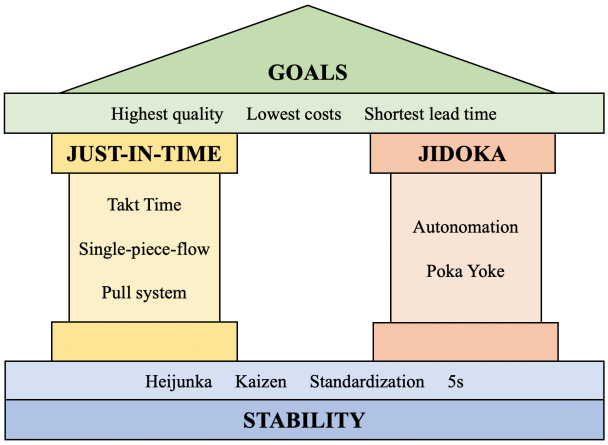
Lean principles just described have become the paradigm for many manufacturing operations, indeed they define the path to follow in order to maximize customer value creation. However, principles' implementation and Lean theories' materialization need dedicated Lean tools and techniques.

1.3 Lean tools and techniques: the TPS House

The Lean implementation focuses on identification and elimination of all forms of wastes throughout supply chain with proper application of Lean tools and techniques: these elements are incorporated in the *Toyota Production System House* – or TPS House – shown in *Figure 1*.

The explanation of the TPS House requires to adopt a bottom-up approach: it is necessary to achieve a certain level of *stability* before implementing *Just-in-Time* and *Jidoka* – the core activities – which, in turn, will optimize *time* and *costs*, while enhancing the *quality* of products and services. Each block is associated to a set of suggested techniques which help to reach a specific purpose.

Figure 1: Toyota Production System House.



Source: Personal elaboration from Shook and Marchwinski (2014).

1.3.1. Stability

Process stability represents the foundation of the TPS House and the first element in which the company should act when it moves toward a Lean system. In this perspective, the Toyota Production System is maintained and improved through iterations of *Kaizen* and *Standardization*: the prerequisite for an efficient and steady Kaizen process is the creation of Standard Operating Procedures. Standard work defines the agreed upon best known method to produce an item using the available equipment, tools, people and materials. The continuous improvement does not only maintain the standards within the whole system, but it also tries to improve the existing ones bringing them to the next level. By using techniques and tools of continuous process improvement any types of waste can be reduced to achieve the TPS goals. As an example, Randhawa and Ahuja (2017) think to *5s*[4] as a technique which exhibits tremendous potential in enhancing the level of quality, productivity, organization work culture, employee morale values and safety.

Additionally, Kaizen can be analyzed in the perspective of smoothing processes in order to eliminate internal and external variation. This refers to *Heijunka*, a tool aimed to distribute evenly the production volume and mix over time, so that the company can avoid long lead times, increasing inventories, greater opportunity of defects and excessive idle time (Black,

[4] The 5s consists of Seiri, Seiton, Seiso, Seiketsu and Shitsuke. It is a methodology aimed to organize the working areas, which focuses on visual order, organization, cleanliness and standardization. It helps to eliminate all types of waste related to uncertainty, waiting, searching for relevant information, creating variation and so on. Moreover, by making everything clear and predictable, clutter is reduced, needed items are always in the same place and work is made easier and faster (Slack et al., 2013, p.484).

2007). It helps to cope with the increasing product diversification and it is a requirement for a successful introduction of *Kanban systems* (Fritze, 2016).

1.3.2. Just-in-Time

The second pillar of Lean is Just-in-Time – or JIT. The term originates from the concept of reducing inventory holding by requiring that parts and components are delivered just as they are required for production and not before (Harrison and van Hoek, 2008, p.184). The concept has been broadened and now refers to postponement of unnecessary resources until they are required. Being a broad management philosophy aimed to waste elimination and quality improvement, JIT looks at getting the right quantity of goods in the right place and at the right time (Ohno, 2013).

Producing JIT means producing according to: (1) *takt time*, considering the pace of the market; (2) *single-piece-flow*, putting all the activities close to each other; (3) *pull system*, keeping inventory at minimum, established levels.

JIT is put into practice by means of a cellular manufacturing approach: the equipment and workstations necessary to produce a product are arranged closely to each other in order to facilitate small lot continuous flow production. The goal is to be flexible for producing a variety of low demand products, while maintaining the same productivity obtained with a large scale production (Modi and Thakkar, 2014).

1.3.3. Jidoka

Finally, the second pillar is Jidoka. It enables operations to separate men and machines for a more efficient work, a concept also called *Autonomation*. As the Jidoka concept developed, it included different control practices to visualize problems. This refers to *Poka Yoke*, a set of techniques that try to prevent fool errors from occurring and to help personnel to avoid making mistakes in their work caused by choosing the wrong part, leaving out a part, installing a part backwards and so on. About this, *Andon* is an information tool which provides instant, visible and audible warning to the operations team in case of an abnormality within a specific area (Modi and Thakkar, 2014). The real time communication that the Andon board enables, attracts instantaneously the attention of the operator as the problem occurs so that it can be straightaway addressed.

To conclude, the first chapter has provided an overview of the Lean philosophy and its critical aspects that companies should consider in approaching to it. The implementation of a Lean strategy is an investment which – on one side – requires relevant resources in terms of time and money, and – on the other one – also means to cope with a significant organizational change. The reason why companies are willing to make such efforts is expressed in terms of success expectations, measured specifically through the economic and financial performance. Accordingly, "the result by which any business in a market economy must be measured is the ability to make enough profit to renew itself" (Womack and Jones, 1996, p.121). However, is it really justified to expect better economic and financial performances if Lean techniques are adopted? Chapter 2 tries to answer this question providing a critical review of the current literature on this topic.

CHAPTER 2: THE ECONOMIC AND FINANCIAL IMPACT OF LEAN: THEORETICAL BACKGROUND

2.1. From the operational to the economic and financial perspective

There is not any doubt about the overall benefits entailed by a successful Lean implementation, also witnessed by the past literature which points out the pivotal role of Lean in enhancing the operational performance of the company. A vision shared – among the others – by Bortolotti et al. (2015) when they confirm a reduction in "process variability, scraps, and rework time, which in turn reduce production costs and lead times and increase process flexibility and quality conformance". Nevertheless, in approaching to Lean, firms are not only interested in the potential operational benefits and the related criticalities, but it is also relevant to have a broad overview about the future implications, both in positive and negative terms. This has led academics to make substantial efforts aimed to deepen the consequences of this production system, moving from the assumption that being involved in any kind of organizational change makes sense only if it allows to reap sustainable rewards over a long period of time, thus leaving out the instant but short-term improvements.

Despite the literature gives real evidence of a positive impact on the operational performance, being Lean a phenomenon in continuous expansion, it is expected to meet more uncertainty in the economic and financial perspective, for which there are still mixed results. Consequently, on one side many authors agree on the positive impact of Lean on the financial performance (Callen et al., 2000; Kinney and Wempe, 2002; Fullerton et al. 2003; Fullerton and Wempe, 2009; Maiga and Jacobs, 2009; Hofer et al., 2012; Furlan and Galeazzo, 2017) even if some others highlight that becoming Lean does not necessarily translate in enhanced profitability. Jayaram et al. (2008) point out a positive relationship of Lean manufacturing to manufacturing performance but not to business performance. Bevilacqua et al. (2017) fear a misapplication of Lean manufacturing tools, which leads to an additional waste of time and money and decreases the confidence of employees and managers in implementing Lean techniques. Thus, given the impossibility of having an indisputable idea of the financial side of Lean, the only way to critically analyze this topic is summarizing the relevant literature as shown in *Table 1*.

Table 1: List of authors whose research suggests that Lean positively impacts (I) or not necessarily influence (NI) the financial performance.

Authors	Sample size	Country	I/NI	Financial indexes	Results
Balakrishnan et al. (1996)	46	N/A	NI	ROA	No differences between JIT and non-JIT firms in terms of ROA. However, in sub-sample stratifications where firms are characterized by high or low customer concentrations, JIT firms that have low customer concentrations exhibit significantly higher ROA than non-JIT firms.
Claycomb et al. (1999)	200	U.S.	I	ROS ROI Profit	The greater the share of JIT transactions, the greater ROI, ROS and firm profitability.
Callen et al. (2000)	100	Canada	I	Profit margin Contribution margin	JIT plants have significantly greater productivity in inventory usage, lower total and variable costs, but not fixed costs, and higher profits and contribution margins compared to non-JIT plants.
Kinney and Wempe (2002)	201	U.S.	I	Profit margin Asset turnover ROA	JIT adopters have higher ROA relative to non-adopters, which derives largely from improved profit margins, suggesting that JIT benefits stem from the elimination of non-value-adding production costs, rather than from reductions in total investment arising from leaner inventories. Relative ROA improvement is concentrated among the earliest JIT adopters.
Fullerton et al. (2003)	253	U.S.	I	ROA ROS Cash flow margin	Three lean bundles (implementation of advanced manufacturing techniques associated with JIT, implementation of procedures for improving products and processes, implementation of JIT purchasing and kanban) are associated with greater firm performance.
Ahmad et al. (2004)	86	U.S.	NI	Operating profits Profit/Sales Cash flow ROI	JIT implementation does not impact on financial performance: it is very difficult to attribute improved financial performance to implementation of a new production system because the financial results are influenced by many factors.
Jayaram et al. (2008)	57	U.S.	NI	ROA	There is a positive relationship between lean design and financial performance, but no relationship is in place between lean manufacturing and firm performance.
Fullerton and Wempe (2009)	121	U.S.	I	ROS	Non-financial measure performance mediates the relationship between Lean and financial performance.
Hofer et al. (2012)	1421	U.S.	I	Net sales Sales growth ROS	Internal lean practices (TQM and TPM) may directly contribute to greater financial performance by lowering operating costs. External lean practices are positively associated with inventory leanness which, in turn, is linked to financial performance.
Nawanir et al. (2013)	139	Indonesia	NI	Sales growth Profit margin ROI	Only few lean bundles contribute to profitability and sales growth.
Bevilacqua et al. (2017)	254	Italy	NI	Sales growth	No direct relationship between lean bundles and firm's performances. The lack of a systematic approach could lead to a misapplication of lean tools, which increase the waste of time/money and decrease the confidence of employees/managers in implementing lean techniques.
Furlan and Galeazzo (2017)	19	Italy	I	ROA	None of the lean bundles is able to explain alone the successful financial performance, but they have to be complemented by other lean bundles. Configurations characterized by low implementation of lean bundles are related to bad financial performance.

Source: Personal elaboration

In light of the results given by Table 1, it is possible to note that the correlation between Lean and financial performance has been empirically investigated by researchers from different facets: the single bundle implementation (Fullerton et al., 2003; Easton and Jarrell, 1998), the multiple bundles implementation (Furlan and Galeazzo, 2017), the relationship with inventory leanness (Hofer et al., 2012; Koumanakos, 2008), the quality award winning (York and Miree, 2004), the organizational size (Terziovski and Samson, 2000), the contribution of operational performance and many other aspects. For what concerns the last point, it is reasonable to think that the first impact of Lean on the financial performance comes from the underlying operating improvements that, in turn, bring to direct and indirect financial savings (Kaplan and Atkinson, 1989). In an analogous way, "since increased process leanness is likely to reduce manufacturing costs, [… many advocates] predict that improvements in process leanness lead to higher profits" (Callen et al., 2000). From a different perspective, as Balakrishnan et al. (1996) state, JIT (1) enhances the competitive advantage of the company due to better quality, higher flexibility and lower lead time, (2) frees up assets and capital, and (3) requires lower inventory levels which improve the asset turnover and increase ROA. However, this is not enough because Kaplan and Norton (1992) point out that "the alleged linkage between operating performance and financial success is actually quite tenuous and uncertain", so that "improving financial performance [would also require] the elimination or profitable redeployment of the resulting slack" (Balakrishnan et al., 1996).

In light of the insights coming from different authors, the present research proposes that Lean management is positively associated with economic and financial performance:

Hypothesis 1*: Lean management is positively associated with the economic and financial performance.*

Despite the conflicting evidence which these studies continue to disclose, in this context the focus will be mainly about the assessment of the financial performance in association with two other different facets: *Leanness intensity* and *Leanness maturity*. These concepts will be introduced in the following paragraphs and analyzed to test the overall progress and impact of Lean.

2.2. Leanness intensity and its implications in the economic and financial performance

The financial gains of Lean can be dependent on how extensively Lean practices are concurrently implemented within the company: from now on this notion will be referred as *Leanness intensity*.

However, before deepening this concept, just a premise must be made. The company decision to further implement new Lean practices – thus moving from a low to a high level of leanness intensity – occurs over time and consequently it could be influenced by the financial performance immediately after the implementation of previous practices. This thought could be a source of bias in case in which companies that early record positive financial results would be more willing to make additional investments to develop a more advanced Lean system. However, Easton and Jarrell (1998) identified different reasons why this could not happen, indeed this thought assumes that "managers expect early overall financial success from their TQM initiatives, that early success does not diminish the perceived need for major organizational change, and that early success drives development of an advanced system [...] rather than just a continuation of initial efforts".

The interest of Lean companies in tools to monitor and control their Lean implementation process, i.e. their leanness intensity, is continuously increasing (Cocca et al., 2019). Nevertheless – even if the literature proposes a multitude of approaches to measure it – the concept of leanness intensity has not yet been deepened to study its effect on the economic and financial performance, which – in contrast – tends to be generally adopted as a benchmark (Bayou and de Korvin, 2008; Srinivasaraghavan and Allada, 2006). Consequently, only a limited number of papers have been identified as consistent with the framework here described.

Primarily, the study of Fullerton and McWatters (2001) finds that the companies which benefit from significantly higher financial rewards are the ones which have largely invested on product and process quality improvements. Some years later, these results have been confirmed by a more in-depth analysis performed by Fullerton et al. (2003): they highlight a significant statistical relationship between measures of profitability and the degree of specific JIT practices used, supporting the premise that extensively adopt JIT manufacturing systems will reap sustainable rewards as measured by improved financial performance, expressed in terms of ROS, ROA and cash flow margin.

Additionally, the study conducted by Bevilacqua et al. (2017) assesses the implementation level of a broad range of Lean practices adopting a seven-point Likert scale. Nevertheless, their study does not test the direct impact of leanness intensity on the economic and financial performance but, rather, the leanness intensity was used to test whether it moderates the relationship between operational characteristics – in terms of product mix variety, product innovation and time effectiveness – and business growth performance. However, their research does not find any support in sustaining the advantages of being a high leanness intensity rather than a low leanness intensity firm.

This current of research also includes the study made by Losonci and Demeter (2013). Initially they classified companies in non-lean, beginner and advanced according to the number of Lean practices they used and according to what extent they use them. In a second step they compared the financial performances in terms of sales, market ratio, ROS and ROI. What resulted was that the operational excellence can be achieved through an extensive use of many Lean practices while the financial success is not as guaranteed.

A critical decision to take in clustering companies according to their leanness intensity concerns the parameter which distinguishes more and less mature companies. In some cases, the authors fix such parameter considering the award winning, being that different awards could be indicative of different levels of intensity in Lean implementations. This is the case of Hendricks and Singhal (2001) who use independent award winning as a proxy for more mature Total Quality Management implementations and supplier award winning for less mature ones. Their results confirm higher mean percent change in operating income and higher sales growth for more mature TQM firms.

Given the limited investigation on this topic, some conclusions can be made from different studies which potentially find their applicability also on the Lean scenario. In particular, Milgrom and Roberts (1995) pointed out that "changing only a few of the system elements at a time to their optimal values may not come at all close to achieving all the benefits that are available through a fully coordinated move, and may even have negative payoffs". This can be translated into the Lean environment in the following way: when a company decides to approach Lean and to introduce only few Lean practices which reach optimal levels, it cannot generally be expected to yield an improvement but, conversely, the company should make a full-scale move – thus implementing remarkable adjustments as part of a systematic and comprehensive transformation of the manufacturing and operation procedures – to reach the best results. To support this insight, Milgrom and Roberts (1995) refer to the example of General Motors which spent some $80 billion during the 1980s on robotics and other capital equipment normally associated with the new methods but it did not make any serious adjustment in its human resource policies, its decision systems, its product development processes, or even in its basic manufacturing procedures, thus resulting in a waste of many of those billions of dollars. This is the result which also White and Prybutok (2001) reached, stating that each element of a JIT system provides some benefits, but its application potentially involves only certain organizational areas and – unless a system perspective is employed – the areas optimize locally, rather than at the organization level. Consequently, the potential

synergic benefits can be fully realized only when all Lean elements are part of an integrated system (Goyal and Deshmukh, 1992; White and Prybutok, 2001).

Being that leanness intensity refers to the extent of Lean practices adoption, the interaction among them – which constitutes the so called Lean bundles – could be a source of synergies. The evidence available demonstrates that Lean bundles might not positively affect the financial outcome. However, only more recently, some authors have started to think that probably the interaction among Lean practices, along with the interaction among Lean bundles, could lead to more certain results in terms of financial performance. From this further level of the analysis, Furlan and Galeazzo (2017) point out that "high financial performances are the result of a specific combination of Lean bundles that work synergistically together", which confirmed the results achieved by the authors who previously sustained the complementarity among Lean bundles (Shah and Ward, 2003; Dal Pont et al., 2008; Mackelprang and Nair, 2010; Furlan et al., 2011a; Furlan et al., 2011b). This premise has led Galeazzo (2019) to test the hypothesis according to which the leanness intensity is positively associated with financial performance. Nevertheless, another time the degree of leanness seems to be not significantly related to financial performance.

To conclude, it seems that investing to achieve a wider, deeper, comprehensive and more advanced Lean implementation level does not necessarily lead companies to experience higher benefits. Consequently, to clarify this concept the following research hypothesis is tested:

Hypothesis 2*: The leanness intensity is positively associated with the economic and financial performance.*

Given the uncertainty which characterizes the literature, it has been tried to find more robust results investigating whether the length of Lean adoption is a crucial element when the business performance is considered.

2.3. Leanness maturity and its implications in the economic and financial performance

Lean implementation is not an easy process indeed it takes long time to be fully implemented, during which continuous improvements must be made (Susilawati et al., 2015). This introduces the notion of *Leanness maturity* – which in this paper refers to the timespan of experience with Lean applications – and the need to make its financial assessment.

The success of Lean companies along the financial and economic dimensions could be related to the length of Lean experience. Although several scholars have provided empirical evidences

about the worth of Lean on performance, some might have neglected that the leanness maturity could be a catalyst in strengthening this relationship.

The financial side of Lean could be potentially associated to the existence of a learning effect. Hendricks and Singhal (2001) initially point out that "firms that are among the early ones to effectively implement TQM would experience the benefits typically associated with being first-to-the-market [indeed they] could improve the quality of their products while lowering costs, and therefore be able to offer higher quality products at the same or lower prices earlier than their competition". If competently employed, the additional experience gathered would allow to gain the most from the adoption of Lean techniques because "the longer a company lean effort the higher its mastery of the lean techniques and tools" (Camuffo and Gerli, 2016). However, the results of Hendricks and Singhal (2001) do not empirically support that earlier implementers are likely to perform better compared to later implementers.

This premise leads advocates to theoretically expect that the maturity positively affects – directly or indirectly – the financial performance. Nevertheless, this is not confirmed by the empirical evidence which suggests that a consolidate leanness maturity does not necessarily translate in superior performances compared to situations of lower leanness maturity. This is witnessed – for instance – by the evidence of Corredor and Goñi (2011) who find that TQM pioneer firms report performance gains over the late implementers. Additionally, according to Kinney and Wempe (2002), even if on one side ROA improvements are mainly concentrated among the earliest Lean adopters, on the other one, by the fifth or the sixth year after the Lean adoption, adopters no longer display better performance in terms of ROA. This is consistent with the idea of first-mover advantage's dissipation as Lean becomes more widely spread.

Additionally, it is reasonably to think that, given the long-run nature of the Lean implementation process, investment returns are not immediately observable (Fullerton et al., 2003). Accordingly, Balakrishnan et al. (1996) sustain that Lean implementation could not positively impact on the short-term profitability for different reasons:

- training and implementation costs related to Lean implementation increase overhead;
- capital expenditure related to Lean implementation increases the asset base, and the associated depreciation lowers profits;
- the lower inventory level of a Lean system increases the dependence on the stability of the company supply chain.

Thus, in the short-term it is difficult to benefit from Lean transformations. Conversely, this could be possible considering a larger timespan, indeed the evidence of Camuffo and Gerli

(2016) is that “firms that have been committed to the adoption of lean principles for a longer time tend to outperform their industry, improving their profitability ratios at a faster pace than that of their competitors”. At this point of the discussion, the dissimilar results showed by the literature could be though as a consequence of the threshold considered to distinguish more and less mature companies within the empirical analysis. Specifically, Camuffo and Gerli (2016) identified the threshold which considerably differentiates Lean companies in terms of business performance at 5 years, meaning that the most successful companies are the ones which do not give up the continuous improvement process after the first problems experienced. Even if the methodology applied was different, the result is similar to the one of Galeazzo (2019) whose research shows that the coefficient of leanness maturity is positive and significant at 10%.

A persistent commitment on Lean has also the beneficial effect of helping to reinforce the organizational culture, explained by Barney (1986) as “a complex set of values, beliefs, assumptions, and symbols that define the way in which a firm conducts its business”. In this context the firm’s organizational culture is a crucial element for its ability to support the Lean implementation and to sustain the Lean efforts (Pakdil and Leonard, 2015). Additionally, it “reflects Lean Management advancements on the Lean journey [becoming a way to find] existing gaps in Lean adoption” (Urban, 2015). What these authors mean is that the success of Lean is dependent – among the other elements – from the organizational culture but the change process requires time, meaning that the maturity is something which matters.

In other cases, some authors tend to focus on the role of time as a moderator on the link between Lean and business performance. Among the others, this is the case of a study performed by Agus and Iteng (2013). This study originates with the identification of two main Lean practices – JIT and New technology and innovation – and both of them exhibit a significant correlation with the financial measures, operationalized by ROS and ROI. In the second step of their analysis, the two Lean practices have been considered separately in order to test the research hypothesis according to which the length of Lean adoption moderates the linkage – on one side – between JIT and ROI, and – on the other one – between JIT and ROS. In both cases the interaction term “JIT x length of lean production” were not significant. Consequently, it is not possible to state that long-term adopters of JIT practices would enjoy higher business returns and a bigger market share than new adopter of JIT. Nevertheless, taking into account the application of the latest discoveries to the design of operations production processes – which refers to the Lean practice “new technology and innovation” – the statistical results show that in this case the maturity plays an important role in enhancing and describing how technology and innovation leads to an increase of both ROI and ROS.

Being maturity a quite debated topic but for which a certain degree of uncertainty still persists, what is discussed in this paragraph concerns the search for a theoretical construct which gives support to a positive or negative role of the time in speaking about Lean. In particular, how fast should firms invest? This is a question at which the literature has tried to answer through the theory of *time compression diseconomies*. Time compression diseconomies – or TCD – move from the assumption that the acceleration of the investment projects have a double effect on the income state: if on one side a company may benefit by an increase of revenues, on the other one this could also inflate costs, thus making more uncertain the final result. Cool et al. (2016) defined TCD as "the additional costs incurred by firms seeking to quickly reach a given level of an asset stock when this stock could be accumulated more economically over a longer period of time". They are generally accepted to apply to any process or activity that involves the accumulation of non-tradeable assets – thus, resources or inputs that firms cannot instantaneously purchase in strategic factor markets (Hawk and Pacheco-de-Almeida, 2018). This means that TCD could potentially find application also within the Lean scenario, even if they have not yet been applied in it. According to this view, the existence of TCD within the Lean environment would mean that any acceleration in Lean investments will be likely to inflate costs at an increasing rate.

This short review of the existing literature tried to be as comprehensive as possible giving insights which come not only from the empirical studies but also from some researches whose elements can find applicability on the study of the leanness maturity. Another time the results are not univocal even if – at least from a theoretic point of view – the long experience with Lean could be a strength. Given these insights, the present research proposes that the leanness maturity is positively associated with financial performance:

Hypothesis 3*: The leanness maturity is positively associated with the economic and financial performance.*

2.4. Leanness maturity and leanness intensity: their simultaneous effect on economic and financial performance

The discrepancy in the current literature about the financial performance of Lean companies is an important issue which requires further exploration. The dissimilar results should be analyzed adopting an attitude of constructive criticism which requires to not neglect the several limitations related to the methodologies applied and the variety of organizational characteristics that differently affect the financial gains. Additionally, the theoretical background which has been provided in this chapter highlights the efforts made in the past to explain – to some extent

– the individual impact of leanness intensity and leanness maturity on the economic and financial performance. The review of the past literature finds that these two phenomena can potentially affect the gains from Lean production, even if a certain degree of ambiguity still persists. To make more deducible and immediate this ambiguity, *Table 2* summarizes the most relevant literature which takes into account the leanness intensity and leanness maturity, even if the logic behind each study is different from each other. The Table specifies whether the authors' insights lead to think about a positive impact of leanness intensity and leanness maturity on the financial performance or whether the ambiguity still persists because the impact is not guaranteed.

Table 2: Summary of the most relevant literature about the impact of leanness intensity and maturity on the financial performance.

Authors	Leanness intensity	Leanness maturity
Agus and Iteng (2013)		Impact not necessarily guaranteed
Balakrishnan et al, (1996)		Positive impact
Bevilacqua et al, (2017)	Impact not necessarily guaranteed	
Camuffo and Gerli (2016)		Positive impact
Corredor and Goñi (2011)		Negative impact
Fullerton and McWatters (2001)	Positive impact	
Fullerton et al, (2003)	Positive impact	
Galeazzo (2019)	Impact not necessarily guaranteed	Positive impact
Goyal and Deshmukh (1992)	Positive impact	
Hendricks and Singhal (2001)	Positive impact	Impact not necessarily guaranteed
Kinney and Wempe (2002)		Negative impact
Losonci and Demeter (2013)	Impact not necessarily guaranteed	
Milgrom and Roberts (1995)	Positive impact	
White and Prybutok (2001)	Positive impact	

What Table 2 highlights is that the researches of Galeazzo (2019) and Hendricks and Singhal (2001) take into account both leanness intensity and leanness maturity. Nevertheless, the literature which investigates the simultaneous impact of leanness intensity and leanness maturity on the economic and financial performance is almost absent. Consequently, to acquire more information about a sort of relationship between leanness intensity and leanness maturity,

here some considerations have been reported even if they do not perfectly fit with the type of analysis needed.

It stands to reason that the relationship between intensity and maturity is worthless because one might think that companies which adopt few Lean techniques are the ones which have adopted Lean for a limited time while companies which adopt a broad number of Lean techniques are the ones which have adopted Lean for a long timespan. This is what expected by Fullerton and McWatters (2001), who found that the longer a company has practiced Lean procedures, the higher is its level of adoption. However, Fullerton et al. (2003) also supports the insight that "firms are able to extract the benefits of even modest implementations, as they gain experience with the JIT system. Thus, the trend results imply that the degree to which some JIT practices are implemented have long-term consequences for firm profitability". This potentially means that a company which adopts a limited number of Lean practices could decide to not make further investments over time because of the satisfactory returns that also a limited Lean implementation intensity ensures. This leads to assume that the association of low leanness intensity with low leanness maturity and the association of high leanness intensity with high leanness maturity are not necessarily confirmed.

Additionally, the literature highlights that the Lean philosophy is based on continuous improvement of products and processes, a goal which could be reached through the involvement of employees in processes which transform Lean practices into activities performed routinely (Peng et al., 2008). However, this is a process which requires time. In other terms, translating this logic and adapting it to such context, the search for continuous improvement could be interpreted as the increasingly extensive adoption of Lean practices, which clearly takes long time: this would mean that the benefits of a higher leanness intensity level requires time to be realized and consequently it is related to a high leanness maturity level.

The only exception which empirically considers both leanness intensity and maturity is the research of Galeazzo (2019), even if her analysis aims to test whether the leanness maturity positively moderates the relationship between leanness intensity and financial performance. The findings indicate that leanness intensity is not associated with financial performance and leanness maturity positively influences financial performance, whereas when these two variables have been considered as an interaction term, it results that the leanness maturity positively moderates the relationship between leanness intensity and financial performance.

After having considered the whole background, the purpose of this paper becomes clearer. Specifically, it tries to address the existent gap investigating whether the intensity and the

maturity of Lean simultaneously affect the relationship between Lean and business performance. Thus, the resulting hypothesis investigated is described as:

Hypothesis 4*: Companies characterized by high leanness intensity and high leanness maturity are positively associated with the economic and financial performance*.

Before presenting the Lean assessment – which is the core of this analysis – a further step is required. Thus, several aspects will be considered in detail and explored in order to answers some questions as: how widespread is Lean within the Italian manufacturing system? Why companies decide to approach Lean? What is the importance of training in a Lean scenario? Are there subsets of Lean companies which perform better compared to the others?

CHAPTER 3: SAMPLE DESCRIPTION AND DATA ANALYSIS

3.1. Data gathering

What has emerged from the literature review is that, despite the large number of extensive and significant contributions provided by academics, there still seems to be scope for addressing the Lean issue from a different perspective and in an even more detailed fashion. Several studies have examined Lean and performance focusing only on single aspects of Lean, consequently in this paper a different approach will be used. In particular, even if the economic and financial side of Lean has been – to some extent – already debated, this analysis makes sense especially for the lack of evidence about the coexistence of *leanness intensity* and *leanness maturity* variables.

To explore the research proposition, the analysis has been performed using data retrieved essentially from two sources: a survey and the AIDA[5] database. Primarily, a *survey* – see *Appendix A* – designed by the Department of Economics and Management "Marco Fanno" of the University of Padua – in collaboration with CUOA Business School – with attached a cover letter reporting the aim of the investigation have been sent to Italian manufacturing companies through the online platform Survey Monkey. Once data have been collected, they had been reorganized in an Excel file, screened to delete non valuable or not complete answers and then integrated with economic and financial information retrieved from *Aida*, e.g. revenues, EBITDA, return on assets, return on investment, return on equity and debt-to-equity ratio.

3.2. Sample description

To validate the sample of firms gathered, some comparisons between the *Sample* and the *Italian manufacturing firms* have been made. The former group is composed of 454 firms which answered the survey submitted while the latter has been defined applying the following criteria to the Aida database:

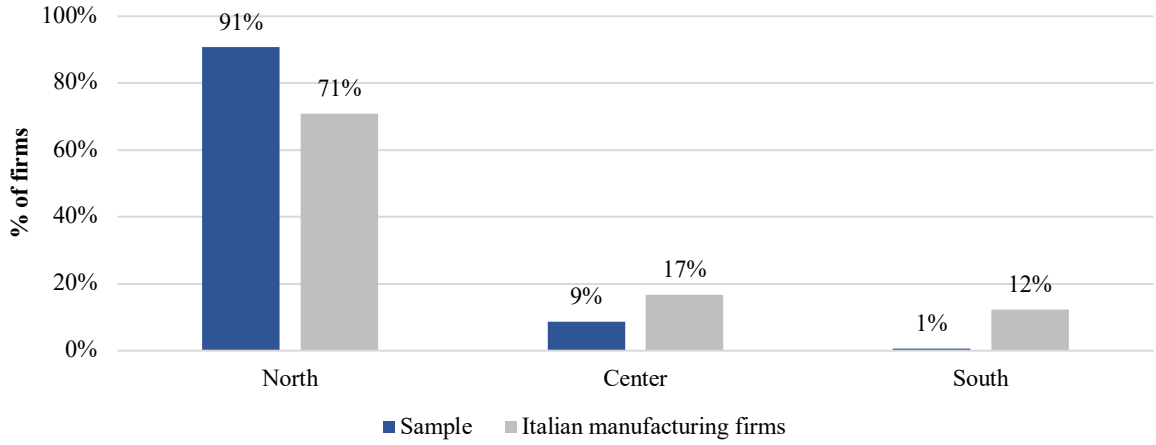
[5] Aida – Analisi Informatizzata Delle Aziende – is a database developed by Bureau Van Dijk which provides complete and detailed economic-financial information on around 200,000 Italian capital companies.

1. NUTS classification, including North-West, South, Islands, North-East, Center;
2. Ateco 2007[6] classification, including companies which range between the two-digit code 10 and 33;
3. companies for which the number of employees in 2018 is available.

Applying these criteria, a sample of 65.184 firms resulted.

The first comparison made is about the geographical distribution, as shown in *Graph 1*. The sample is quite under-representative of the Center and South of Italy while it is over-representative of North Italy. However, being that the industrial concentration in Italy is placed mainly in the North and the sample focuses on this area, it is possible to think that data are reliable.

Graph 1: Distribution by geographical location [n^S=454; n^M=65.184][7].

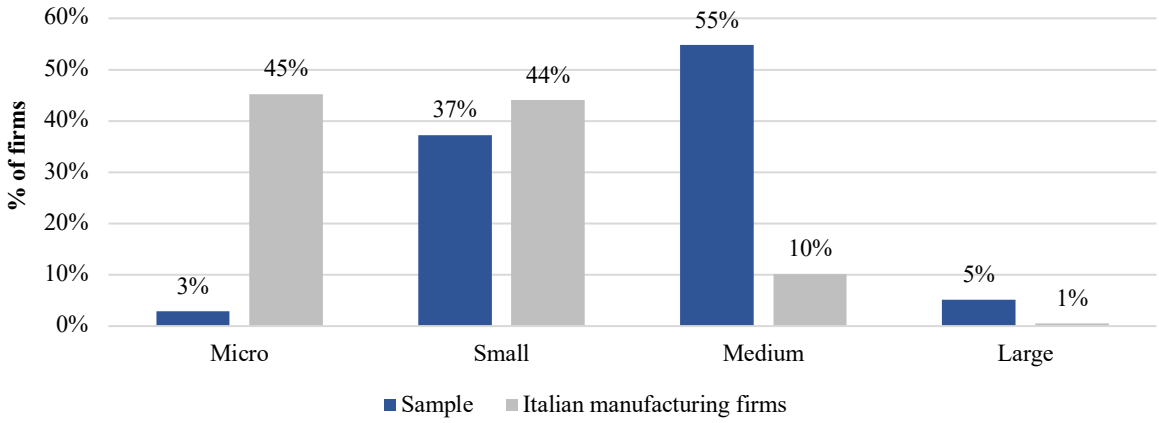


However, the analysis of the geographical distribution is not enough for the reliability of the sample. For this purpose, analogous comparisons have been made for the size and for the distribution by sector.

The investigation according to the size – *Graph 2* – requires the partitioning of the sample, which has been made according to the following criteria: companies until 9 employees were considered micro; companies with 10 to 49 employees were considered as small; companies with 50 to 499 employees were considered as medium; companies with 500 or more employees were considered as large. This classification highlights, on one side, the under-representativeness of the sample for small but mostly for micro firms and, on the other one, the strong over-representativeness of the sample for medium and large firms.

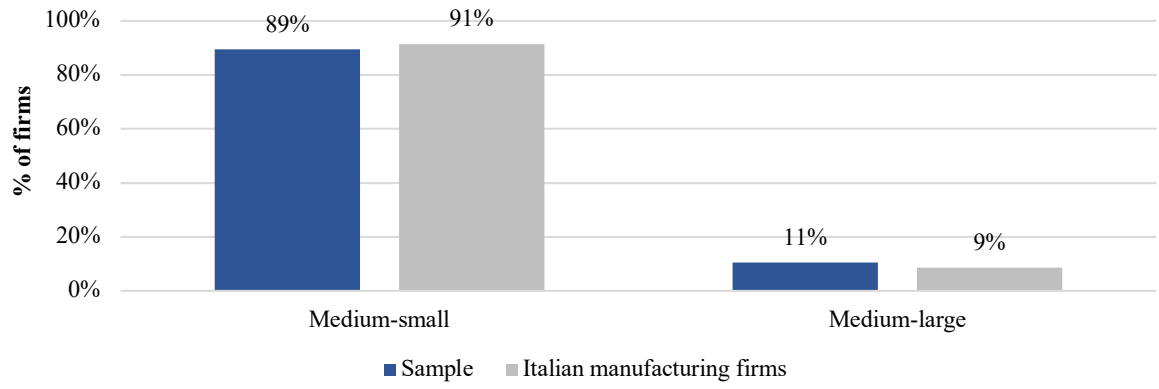
[6] Ateco code is an alphanumeric combination which classifies the economic activities. Here the *Ateco 2007* has been used, a classification which is in force from January 1, 2008 and approved by ISTAT.
[7] n^S refers to the size of the sample (454 firms); n^M refers to the total number of Italian manufacturing firms – retrieved from the Aida database – which are consistent with the criteria 1-3 above mentioned (65.184 firms).

Graph 2: Distribution by companies size [n^S=451; n^M=55.714].



Nevertheless, the Italian industrial environment is characterized mainly by small and medium enterprises – which represent the 92% and 54% of the sample and of the Italian manufacturing firms, respectively – and consequently it is meaningful to focus on these categories. Specifically, it is worth to analyze especially the composition of the medium firms due to the existing gap between the percentage of companies in the sample and the percentage of Italian manufacturing firms. As expected by the context in which the analysis is made, the subdivision of medium-sized companies between medium-small – the ones with 50 to 249 employees – and medium-large – the ones with 250 to 499 employees – exhibits, in *Graph 3*, a perfect consistency: 89% against 91% for the former group and 11% against 9% for the latter.

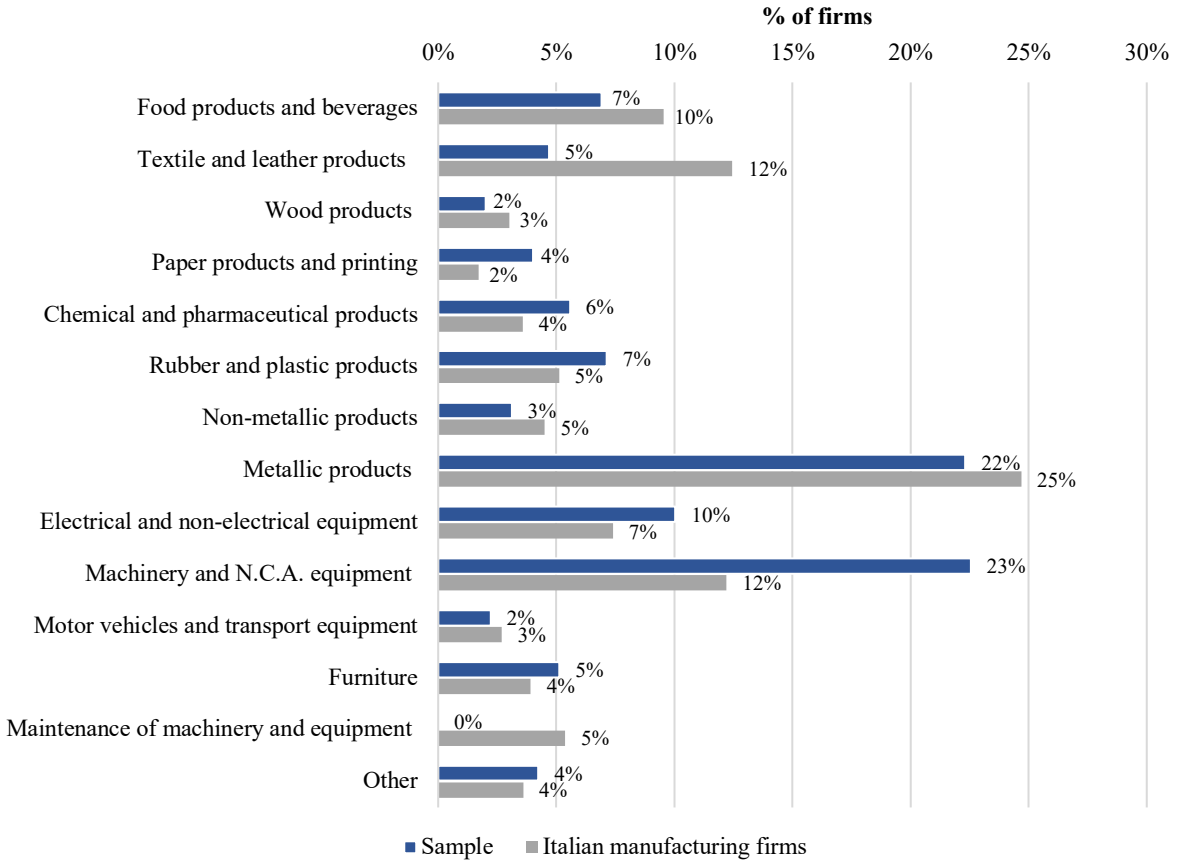
Graph 3: Subdivision of medium-sized firms [n^S=247; n^M=5.677].



The last step to validate the sample collected consists in evaluating the repartition of companies in different sectors of the wider group of manufacturing firms. For the purpose of this analysis, a firm must have a primary two-digit Ateco 2007 code within the range of 10 and 33, which indicates – as a matter of fact – that all firms of the sample are part of the "manufacturing activity" section. Once again *Graph 4* confirms the overall representativeness of the sample for its coherence with the distribution by sector of the Italian manufacturing firms despite, to some

extent, a significant deviation in the "Machinery and N.C.A. equipment" sector. Moreover, companies which answered to the survey are concentrated predominantly in three industries (55%): metallic products (Ateco 24 and 25), electrical and non-electrical equipment (Ateco 26 and 27), machinery and N.C.A. equipment (Ateco 28).

Graph 4: Distribution by sector [n^S=448; n^M=65.184].



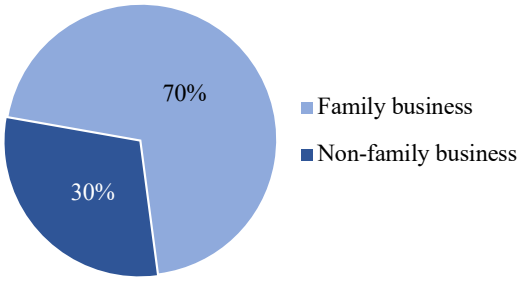
These preliminary analyses allow to confirm the reliability of the sample gathered, which will be exploited for making further elaborations. Thus, the following steps consist in providing, firstly, a general overview of the firms and their organizational characteristics and, secondly, information specifically on Lean firms. Only after that, the heart of this paper will be presented through an even more detailed level of examination, giving evidence of the differences between Beginner, Advanced and Outsider firms characterized by different levels of leanness maturity.

3.2.1. General overview and organizational characteristics of the sample

The survey submitted to Italian manufacturing firms consists of two sections. The first one gives an overview of the companies and their characteristics – for instance, turnover, number of employees, export strategy, main market, type of layout, technologies 4.0 – while the second section focuses only on Lean companies.

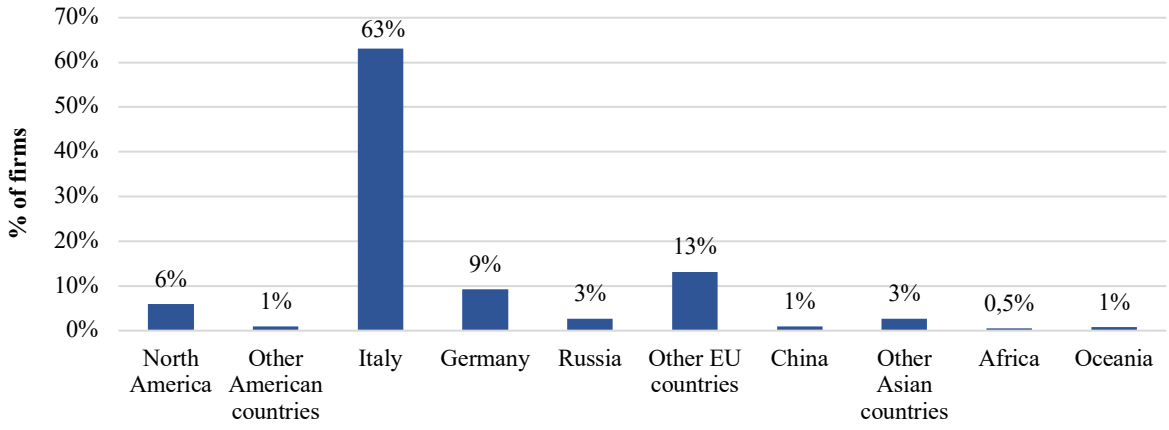
One of the first questions of the survey was about the corporate governance, in particular about whether the firm is a family business or not. With the meaning of a company whose owners are directly and effectively involved in its management, family businesses within the sample account for 70% of the total sample, as shown in *Graph 5*. This percentage reflects somehow the composition of the Italian system in which more than 85% of Italian firms are family businesses, as witnessed by a report of AIDAF[8].

Graph 5: Family businesses [n^S=442].



This large percentage of family businesses does not mean that they are not interested to the internationalization, even if the Italian market is considered the main market by the majority of firms under assessment (63%), as reported in *Graph 6*. Foreign markets are considered relevant for the remaining 37%, percentage which can be partitioned in 25% of companies which consider a European country as their main market while only a very limited part of the sample (12%) focuses its business in an extra-continental context.

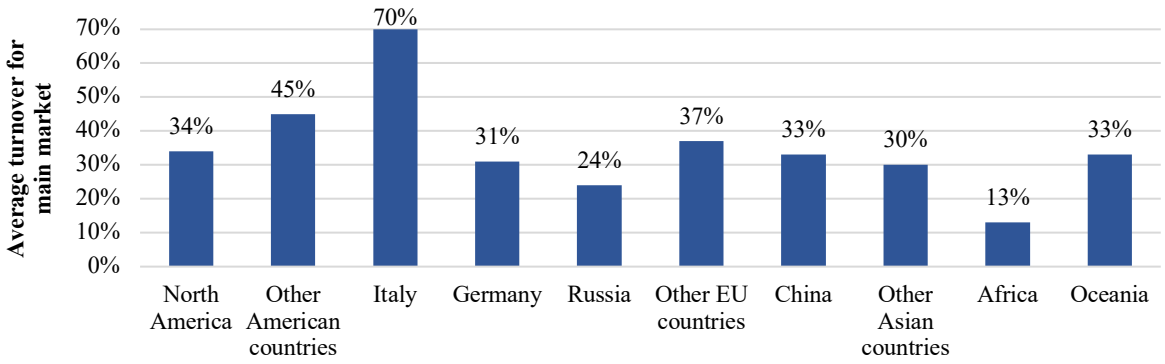
Graph 6: Main markets [n^S=403].



Simultaneously, also information on the average turnover realized by firms in their main market can be provided – *Graph 7*: except for Italy in which the related average turnover is 70%, for all the other markets the percentage of turnover is equal or lower than 45%.

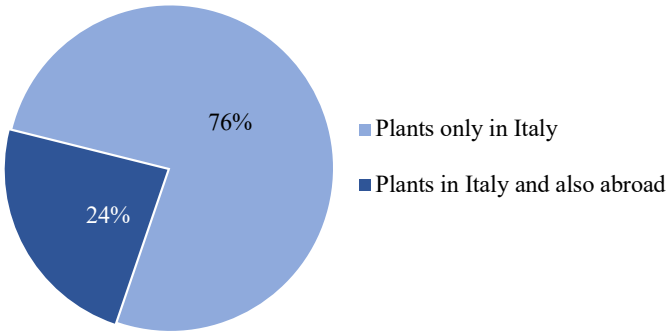
[8] AIDAF – Associazione Italiana Delle Aziende Familiari – is an association of more than 200 family businesses which is involved in training and accountability of members, institutional projects and exchange of experience.

Graph 7: Average turnover (on total turnover) realized in each main market [n^S=403].



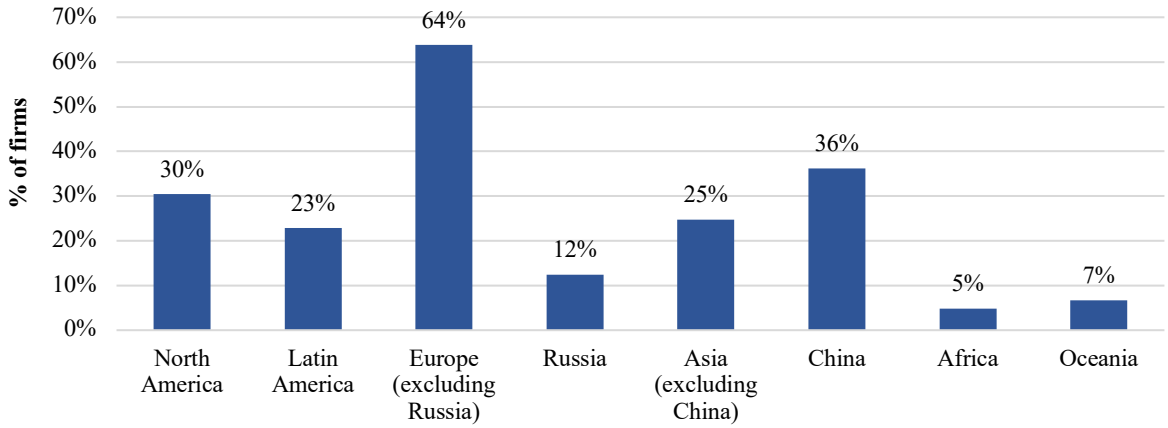
The fact that the majority of firms have their main market in Italy partially explains why 76% of the companies do not have any plant abroad – *Graph 8*.

Graph 8: Establishment of plants abroad by Italian firms [n^S=444].



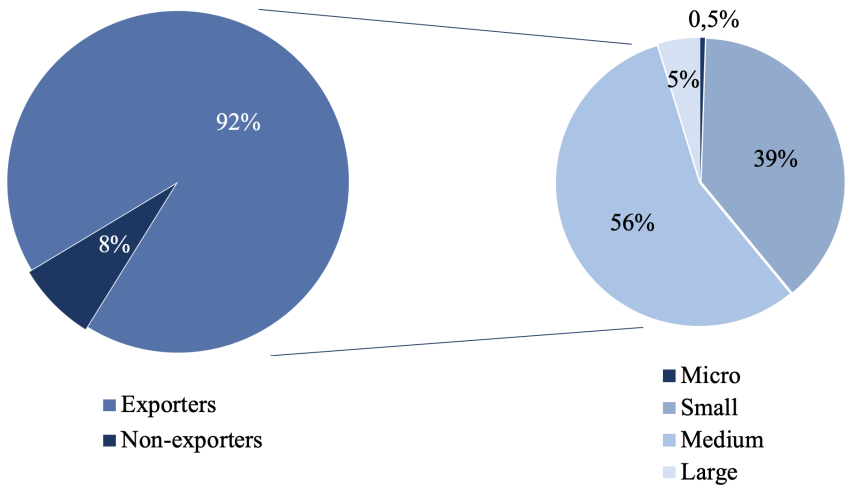
Considering only the 24% of companies witch own plants both in Italy and in at least one foreign country, it could be interesting to understand where they prefer to locate their plants as shown in *Graph 9*. The majority of firms establishes facilities in Europe (64%), an expected result after having defined – in Graph 6 – Europe as the main market for 25% of the companies.

Graph 9: Manufacturing facilities location [n^S=105].



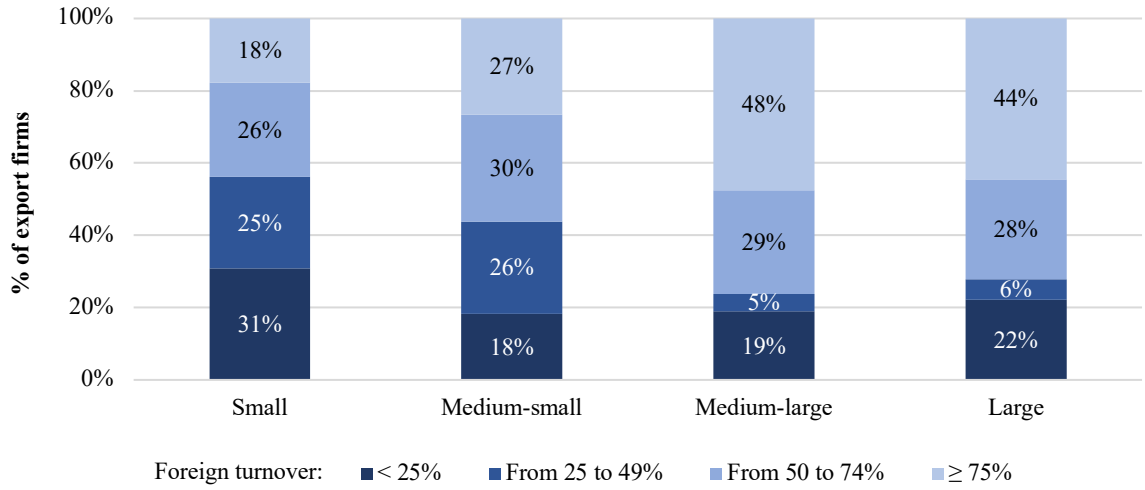
In the international world which characterizes these days, the limited percentage of companies with manufacturing facilities also abroad (24%) means that Italian companies are extensively involved in export activities. Indeed, this is exactly what results in *Graph 10*, whose usefulness is twofold. On one side it witnesses that 92% of the companies trade domestic products in foreign countries while only 8% are not involved in exports, thus limiting their efforts in the Italian market. On the other side, it is also possible to have an idea of the repartition of exporters according to their company size: considering only the 92% of companies which export, 39% of them are small companies, 56% are medium and 5% are large.

Graph 10: Distribution of exporters and non-exporters [n^S=409].



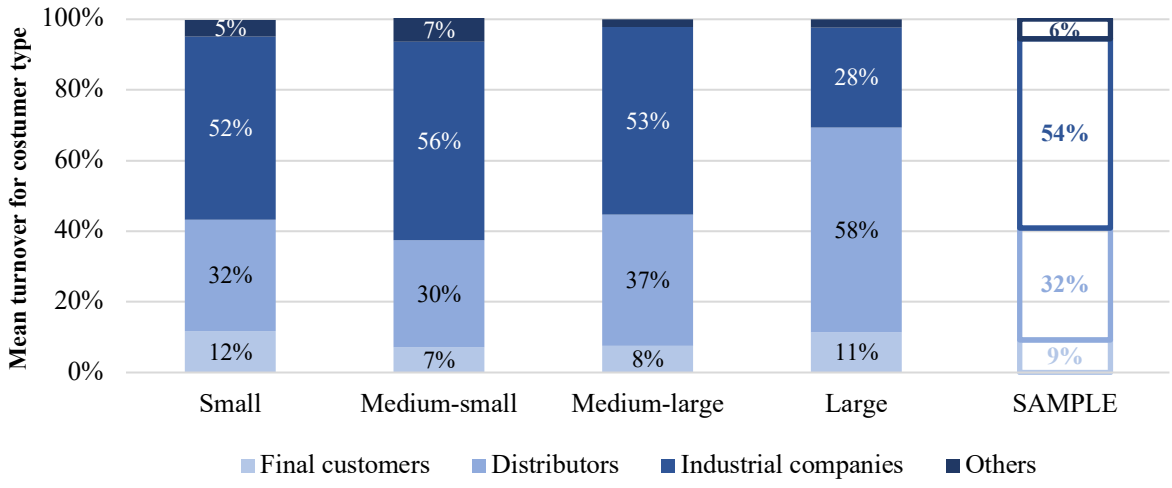
Focusing the attention another time on the 92% of companies which export, it would be meaningful to analyze the percentage of their turnover realized abroad, making more interesting the analysis classifying such companies according to their size. Being that micro companies which export are only 0,5%, *Graph 11* focuses on small, medium-small, medium-large and large companies, while neglecting the micro ones. As expected, it is possible to note a reduction in the number of exporters associated to limited ranges of turnover realized abroad – meaning the ranges of turnover "< 25%" and "from 25 to 49%" – as the company size becomes larger. Indeed, 56% of small companies have a foreign turnover – compared to total turnover of 2017 – which is equal or lower than 49% while, for large companies, the percentage reduces to 28%.

Graph 11: Distribution of exporters by foreign turnover and company size [n^S=377].



According to this classification, some other analyses can be made in order to identify potential differences among companies with a different size. The first one is about the type of customers to which products are addressed. *Graph 12* gives a clear representation that the composition of turnover 2017 by customer type is more or less the same regardless the size of the companies, except for large companies in which the turnover is not anymore related mainly to industrial companies but rather to distributors (58%). At the same time, considering the overall sample, on average the turnover is mainly associated to industrial companies (54%), followed by distributors (32%) and final customers (9%).

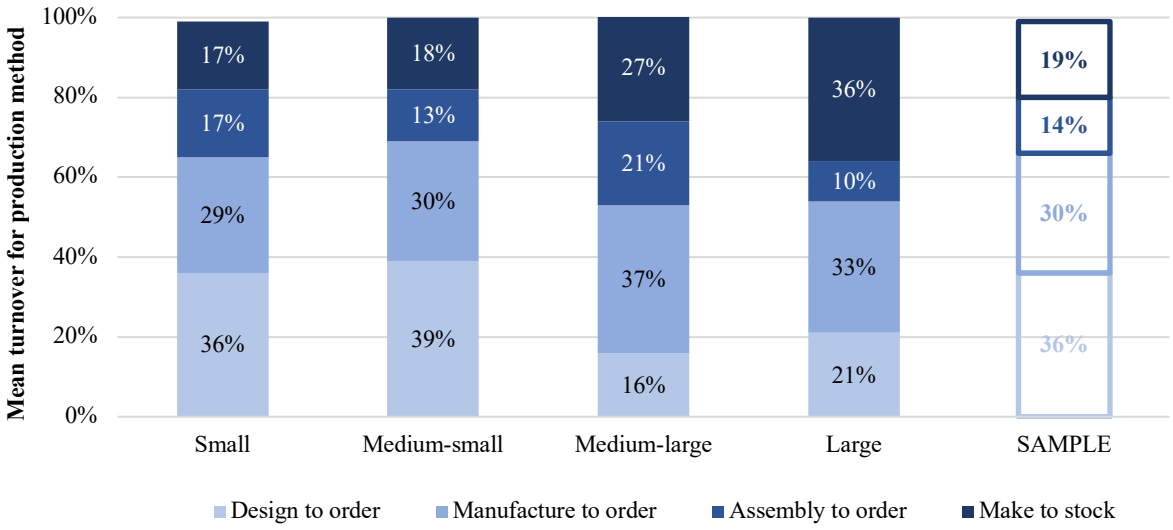
Graph 12: Distribution of firms according to mean turnover for customer type [n^S=391].



The customers with which companies relate can potentially influence the production approach adopted within the company in the manufacturing field. At this purpose, survey respondents had to indicate the percentage of their turnover which is related to Design to order, Manufacture to order, Assembly to order and Make to stock. The first remark on *Graph 13* is that, regardless

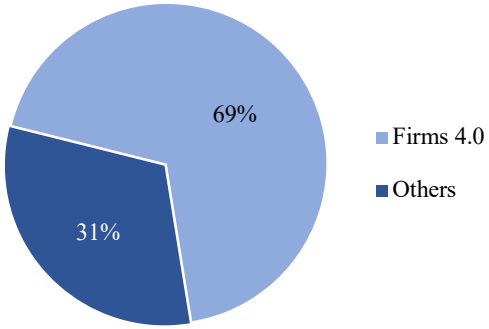
the company size, Design to order – a production approach in which each part is designed and assembled specifically according to the customer order – and Manufacture to order – a production approach in which manufacturing starts only after having received the customer's order – are the predominant sources of turnover.

Graph 13: Mean turnover related to different production approaches [n^S=412].



The production field can be analyzed from a different perspective, thus introducing the role of the technology and the related concept of Industry 4.0. "The term Industry 4.0 stands for the fourth industrial revolution which defines as a new level of organization and control over the entire value chain of the life cycle of products" (Vaidya et al., 2018). This new trend toward an increasing autonomation and digitalization of the manufacturing environment is witnessed by *Graph 14* which, coherently, shows that 69% of firms are part of the Industry 4.0.

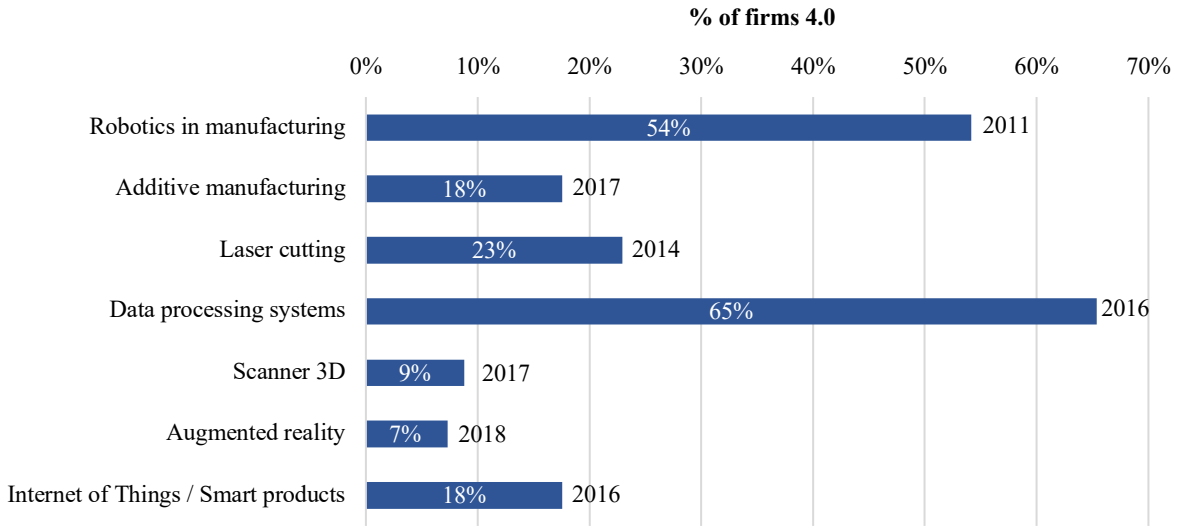
Graph 14: Industry 4.0 [n^S=299].



In this framework, a company has been considered as part of the Industry 4.0 if it adopts at least one technology 4.0. Among the 69% of firms 4.0, each technology has a different degree of implementation within the organizational context, an aspect which has been deepened in *Graph 15*. The most adopted technologies are data processing systems (65%) and robotics in

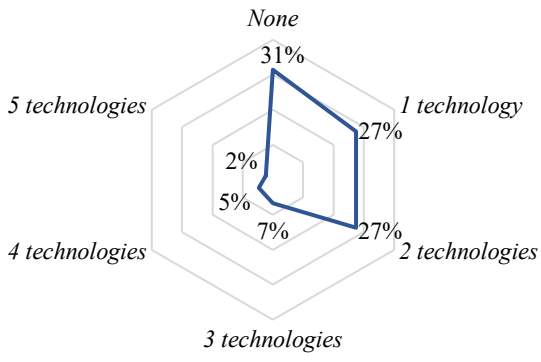
manufacturing (54%), followed by other technologies with a lower degree of implementation: laser cutting (23%), additive manufacturing (18%), Internet of things (18%), scanner 3D (9%) and augmented reality (7%). As anticipated above, this phenomenon is quite recent and this is the reason why all technologies have been adopted on average in the last 10 years. The most recent technology is augmented reality indeed the median year of adoption is 2018, and this for sure explains the relatively low degree of implementation. Conversely, robotics in manufacturing is the earliest technology 4.0, adopted on average in 2011.

Graph 15: Diffusion of technologies 4.0 and median year of adoption [n^S=205].



A further step of the analysis can be reached exploring the distribution of firms according to the number of technologies 4.0 adopted over the seven technologies just mentioned. *Graph 16* shows that 31% of the sample declare to not adopt any technology, half of the sample adopts one (27%) or two (27%) technologies, while only a further limited number of firms adopt three (7%), four (5%) and five (2%) technologies, without neglecting that no company adopts six and seven technologies simultaneously.

Graph 16: Number of technologies 4.0 adopted [n^S=299].

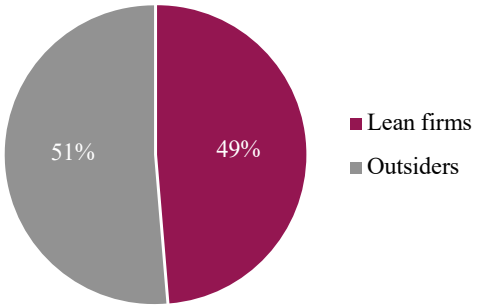


The analysis made until now had the purpose to present some relevant features of the sample gathered through the survey. After this premise it is possible to take some steps forward toward the heart of this paper. Consequently, in order to approach the objective, the analysis needs to move the focus in understanding primarily some aspects of Lean companies. This is the reason why the next paragraph will aim to capture the differences between firms which implement Lean tools – thus, the Lean companies – and firms which do not implement any Lean tool – thus, the Outsider companies.

3.2.2. General overview and organizational characteristics of Lean companies

The purpose of the survey submitted to Italian manufacturing firms consists in the investigation on Lean firms. Indeed, after some general questions at which all companies could answer, the survey opens its second section with the question "*Do you apply any Lean techniques?*". The answer "*Yes*" or "*No*" was the element which allowed to identify Lean and Outsider firms, respectively. The result was that 221 companies out of 454 answered "Yes", thus representing 49% of the sample as shown in *Graph 17*.

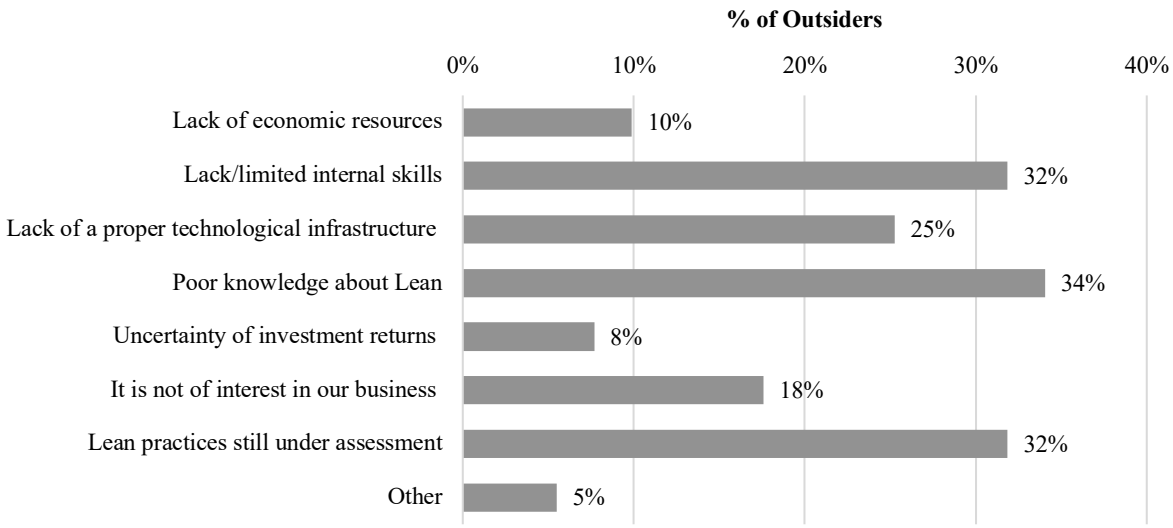
Graph 17: Distribution of Lean firms and Outsiders [n^L=221; n^O=233][9].



Companies which answered "*No*" are 233 and, for them, the survey ended only after having investigated their reasons behind this choice. What the survey suggests is that the most common reasons for the non-implementation are: poor knowledge about Lean (34%), lack or limited internal skills (32%), still assessment phase of Lean techniques (32%) and lack of a proper technological infrastructure (25%), as reported in *Graph 18*. These are all internal elements which make difficult Lean implementation, but also the financial aspect needs to not be neglected (10%). What is worrying, however, is that as many as 18% companies answered that Lean is not of interest in their business, meaning that they do not understand how it is worth within the manufacturing environment.

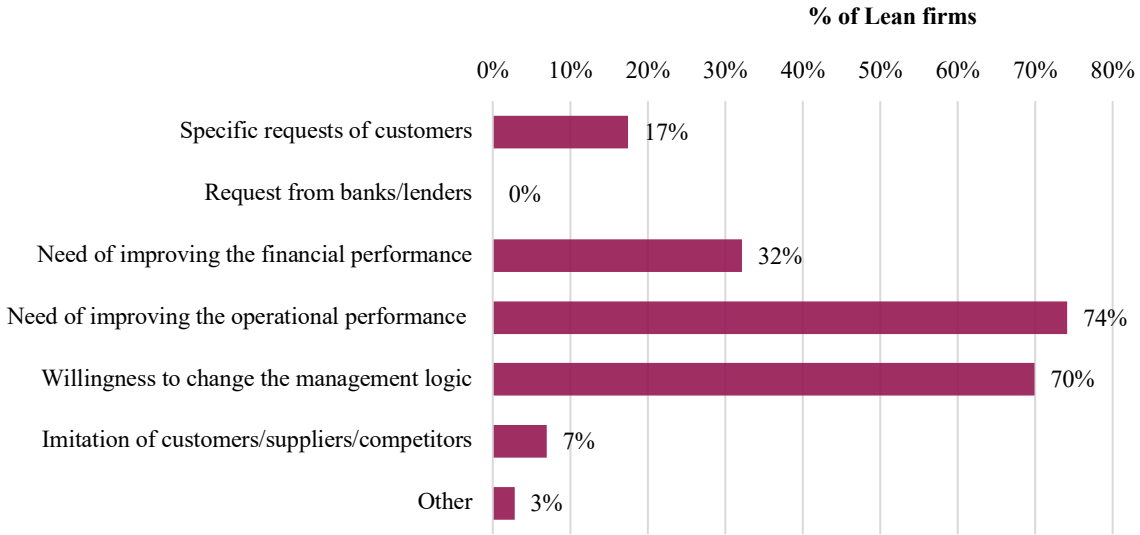
[9] n^L refers to the number of companies within the sample which adopt Lean practices (221 firms); n^O refers to the number of Outsider firms (233 firms).

Graph 18: Simultaneous reasons why companies do not approach to Lean [n^{O}=91].



Conversely, companies which answered "*Yes*" are considered Lean and for them the survey continued with some more questions. In an analogous way, these companies were asked the reasons behind the decision to approach Lean – *Graph 19*. As expected, the main drivers are the need to improve the operational performance for achieving a higher degree of efficiency (74%) and the willingness to change the management logic (70%). The need to improve the financial performance is one reason with which only a limited number of companies agreed (32%), probably explained by the uncertainty of a direct relationship of Lean with the economic and financial performance.

Graph 19: Simultaneous reasons why companies approach to Lean [n^{L}=143].



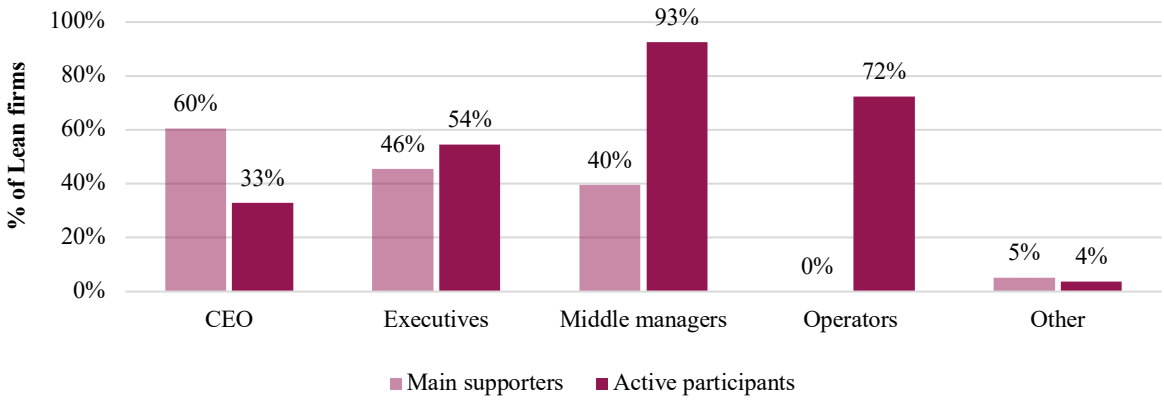
At Lean companies it was required to provide more information about their specific approach, thus identifying the following main areas of investigation: I) Soft Lean practices; II) Market; III) Lean and Industry 4.0; IV) Lean techniques.

Part I: Soft Lean practices

Lean tools can be classified in hard and soft practices according to their nature. "Soft practices concern people and relations, while hard practices refer to LM technical and analytical tools" (Bortolotti et al., 2015). Companies tend to adopt more extensively hard practices, neglecting the importance of soft tools such as group problem solving, employees involvement and training. This is the reason why here below some data about the role of people within Lean firms will be provided.

First of all, the survey has deepened who are the main supporters of Lean practices, identifying primarily the Chief Executive Officer (60%), followed by the executives (46%) and middle managers (40%) – *Graph 20*. People involved in these roles often have also a function of active participants in Lean transformations – for instance, participation to kaizen workshop – even if the distribution presents dissimilarities: there are higher percentages of active participants by middle managers (93%), operators (72%) and executives (54%) compared to the ones of main supporters. The last remark on Graph 20 focuses on the fundamental role of the CEO who plays a simultaneous role of active participant and main supporter in 27% of Lean firms.

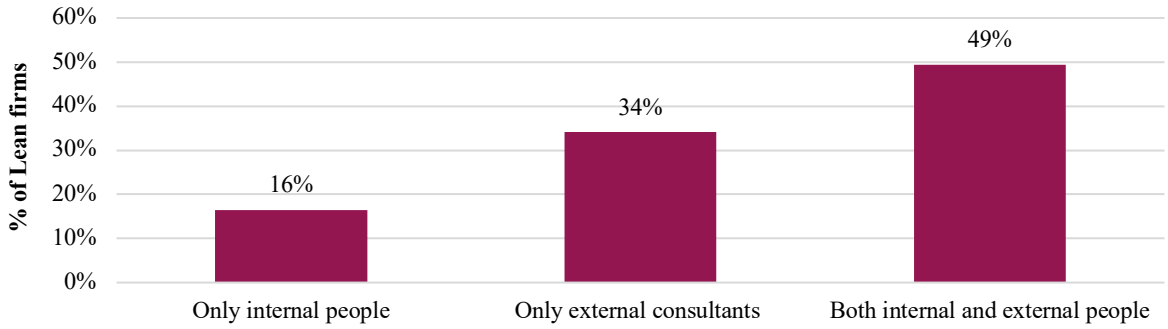
Graph 20: Main supporters and active participants of Lean practices [n^L=134].



Lean implementation requires the involvement of people aimed at continuous improvement. Companies can reach this purpose employing – as shown in *Graph 21* – only internal people (16%) or only external consultants (34%). However, given the sophisticated nature of Lean, it is better the participation of both internal and external people, as 49% of Lean companies do. Netland (2016) made a clarification stating that "it is those plants that are new to lean that

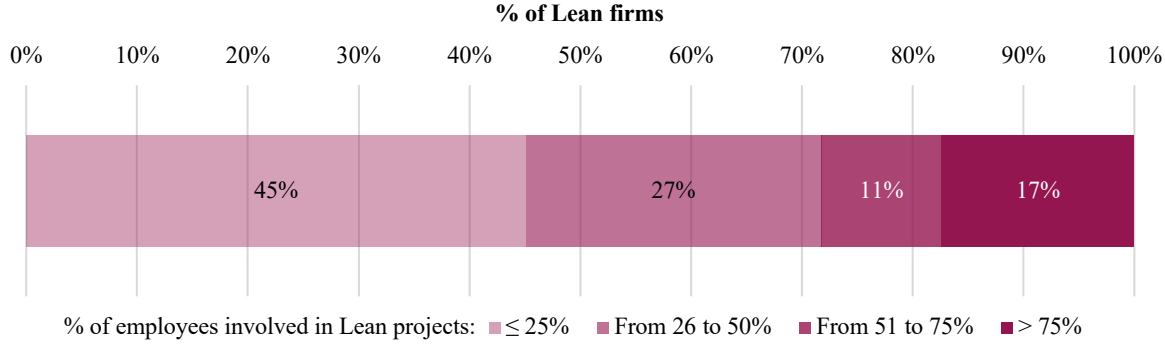
emphasize the use of external experts more. [...] On the whole, it is clear that accumulating local knowledge is considered much more important than the use of consultants. However, in the early stages of the lean journey, external consultants and experts can help build this local knowledge".

Graph 21: People involved in Lean implementation [n^L=176].



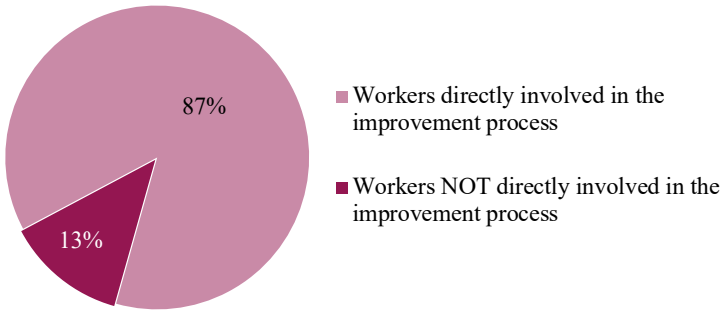
Internal people involved in Lean projects include also employees. "Motivated and engaged employees tend to contribute more in terms of organizational productivity" (Mehta and Mehta, 2013) and this translates in more profitable organizations than those with lower levels of employee engagement. However, this is one of the greatest challenges facing companies in this decade. *Graph 22* gives representation of the percentage of companies which involve different ranges of employees – on total employees – in Lean projects. Almost the half of Lean companies involve until 25% of their employees. For the other ranges of involvement, the percentages are lower, especially for the range 51-75% which include only 11% of Lean companies. Despite the motivated importance of engaged employees, as the percentage of employees involved in Lean projects increases, the tendency is a slight but continuous reduction in the number of firms, meaning that the ones which involves high percentages of their employees in Lean projects reduces to a rather limited number. For instance, organizations in which everyone is involved in Lean projects represent only 6% of total Lean companies.

Graph 22: Employees involved in Lean projects [n^L=184].



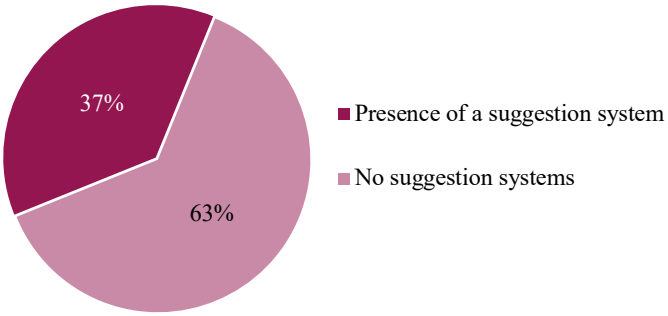
Lean companies are encouraged to make investments aimed toward employees engagement because – as found by Mohr and Zoghi (2008) – the degree of job "satisfaction [is] positively associated with high-involvement work practices [which, in turn] correlates with improved job performance". This is the reason why 87% of companies declare the direct involvement of their workers in the improvement process – *Graph 23*.

Graph 23: Direct involvement of workers in the improvement process [n^L=210].



The direct involvement of workers in the improvement process also relates to the organizational choice of implementing a suggestion system. Suggestion programs can potentially translate in concrete and beneficial changes in different organizational areas. Moreover, they allow improvements through ideas generation, thus representing a source of creativity for the organization. Indeed, according to Carrier (1998), "the introduction of suggestion programs is used increasingly by companies as a functional strategy to mobilize the creative intelligence of their workforce". Nevertheless, from *Graph 24* it seems that the potential of this system has yet to be fully understood by companies as only 37% of them make its use.

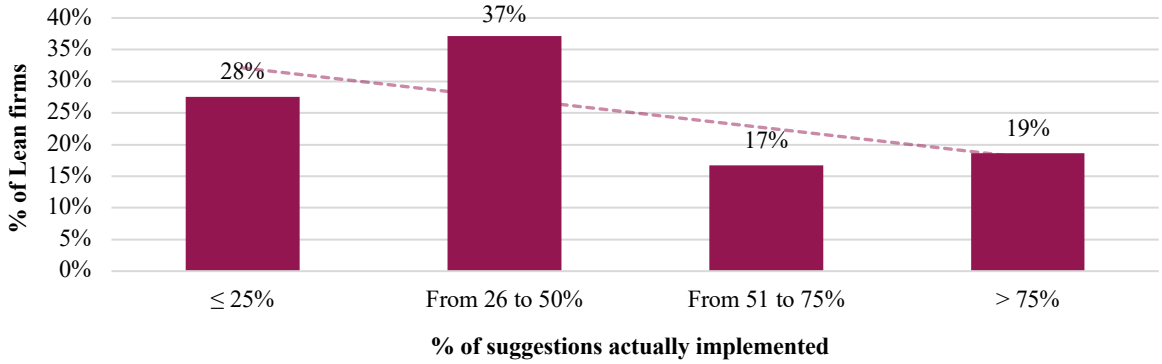
Graph 24: Utilization of a suggestion system by Lean companies [n^L=204].



One possible criterion to assess the level of success achieved by the suggestion programs is the percentage of ideas considered valuable and actually implemented by the companies. In *Graph 25* it is possible to see that the majority of Lean firms implement until 50% of the suggestions

and then there is a drastic reduction of firms when a larger percentage of suggestions actually implemented is taken into account. Accordingly, the tendency line has a slightly negative slope.

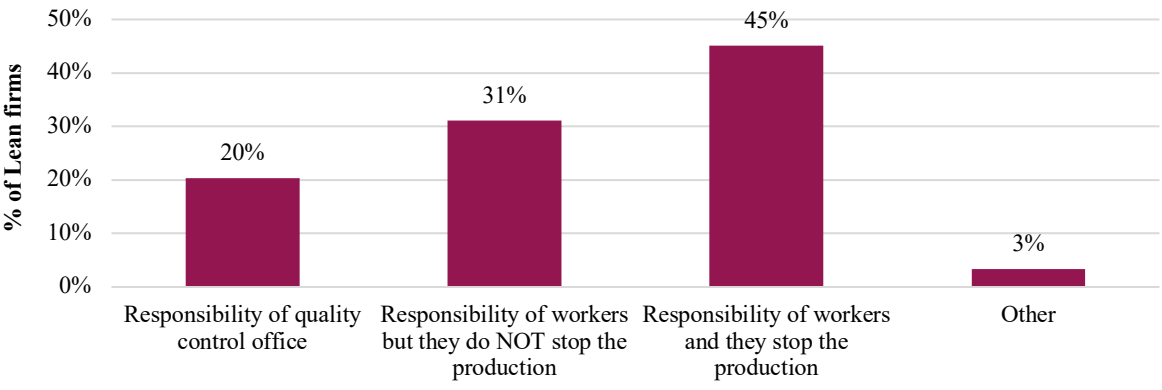
Graph 25: Actual implementation of suggestions from employees [n^L=156].



The research made by Carrier (1998) highlights that "in the larger firms, more than 30% of all ideas received were retained and/or rewarded. This [percentage] rises to nearly 50% in the SMEs". These results are perfectly in line with the sample gathered, which evidences that large firms have a median percentage of suggestion implementation of 30% against the 50% of SMEs. The acceptance rate may – at first glance – seem high but there are reasonable explanations of this, firstly the straightforwardness of implementation of the ideas submitted, their low investments required and their subsequent simplicity of acceptance.

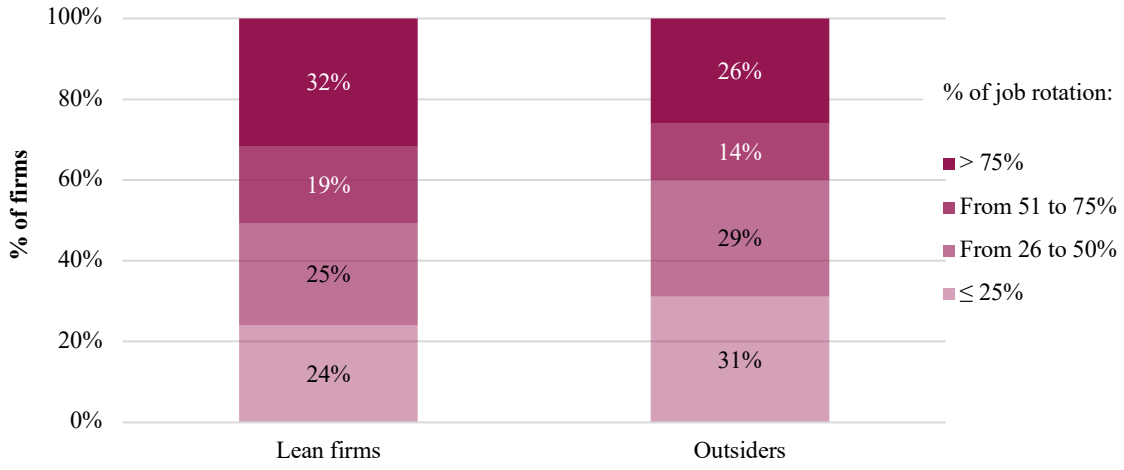
Particularly, the suggestions provided by workers are extremely useful in case of defective products and anomalies because of their deep knowledge, being directly involved in the manufacturing process. Indeed, *Graph 26* shows that only 20% of Lean companies attribute such responsibility to the quality control office while 76% of them rely on workers. However, a distinction needs to be made: 45% of Lean companies allow workers to detect possible product or process anomalies and stop the production process in order to implement the needed corrective actions while 31% do not allow workers to stop the production process.

Graph 26: Approaches to detect defective products and anomalies [n^L=206].



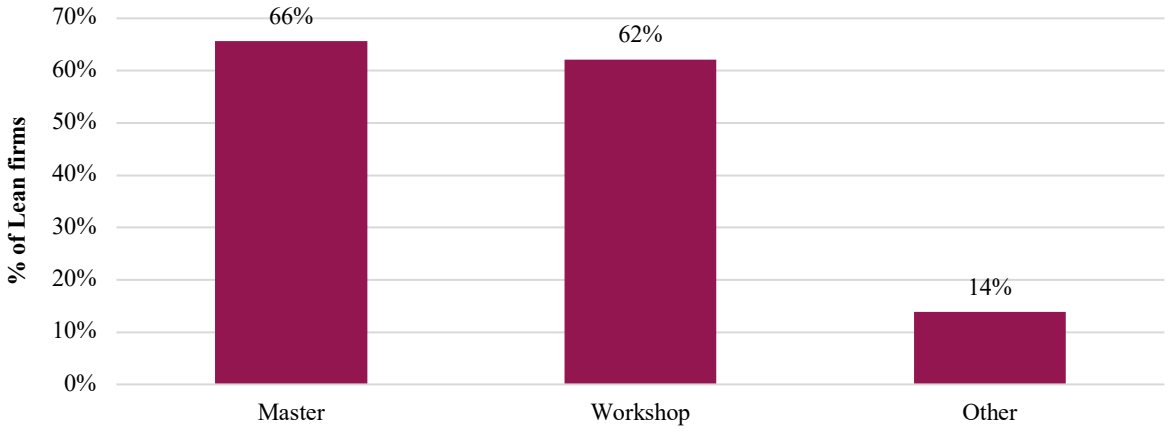
Lean companies make an extensive use of multifunctional teams as a way of work organization aimed to engage employees effectively, which simultaneously results in an additional benefit to the company by way of multi-skilled employees. Karlsson and Ahlström (1996) aver that "the percentage of employees working in multifunctional teams is much higher than in traditional work organizations": this is exactly what confirmed by *Graph 27*. In particular, taking into account only the two highest ranges of distribution of blue collars involved in job rotation – thus, the range from 51 to 100% – the result is that the percentage of companies which make involved at least the half of their workers is 51% and 40% in Lean and Outsider firms, respectively. 60% of Outsiders involve less than the half of their workers, against the 49% of Lean companies. There are also companies which do not rely on job rotation, but they only account for a very limited percentage.

Graph 27: Blue collars involved in job rotation [n^L=195; n^O=215].



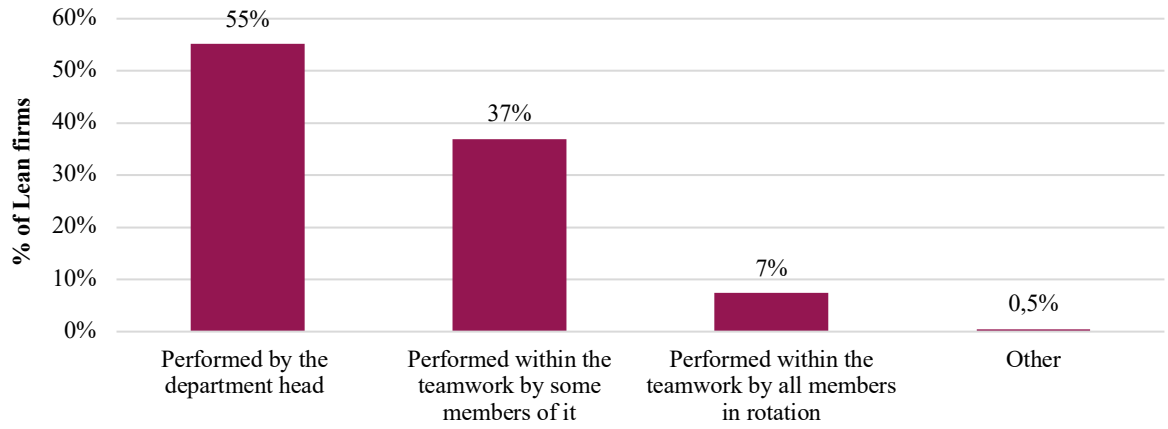
Achieving high degrees of multifunctionality can be very difficult because of the reluctance of employees who had performed the same tasks for years and then suddenly they are required to do something else (Karlsson and Ahlström, 1996). Consequently, to overcome this issue and reach even better results in terms of multifunctionality and, broadly, in terms of engagement, it is required to continuously make investments in staff training. The actions undertaken by Lean firms already follow this route – as *Graph 28* represents – with 66% of companies which invest in master – thus, training courses for employees, executives and managers – and 62% of companies which invest in workshop – thus, training courses for workers.

Graph 28: Investments for Lean training [n^L=195].



Finally, for what concerns soft lean practices, the last remark in terms of responsibility and supervision tasks allocation can be made. What results from *Graph 29* is that in 55% of Lean companies the responsibility is centralized, meaning that the supervision and control activities are performed by the department head. In a Lean production system, it is expected to find a broad consensus in the decentralization of responsibilities, a result which is only partially confirmed by Graph 29. This occurs because ideally the best situation would be the one to follow a path of job enrichment, "allocating extra tasks which involve more decision making, greater autonomy and greater control over the job" (Slack et al., 2013, p.265). Specifically, in 37% of the cases supervision and control activities are performed directly within the teamwork by one or more members of it while for the last 7% the activities are performed directly within the teamwork and they are allocated to all members in rotation.

Graph 29: Approaches to allocate the responsibilities and supervision tasks [n^L=203].



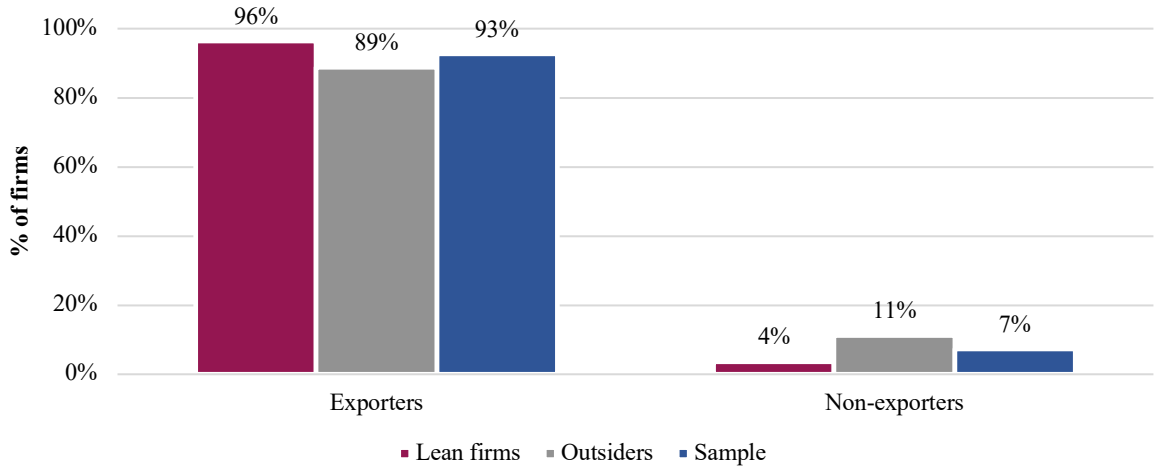
To conclude, Lean management literature has extensively investigated the role of people in the Lean environment and it seems that practitioners agree on the influential contribution of soft Lean practices for succeeding with Lean over time.

Part II: Market

To present the most important features of the sample and – specifically – of Lean companies, the analysis has been organized in different areas. The second one concerns some information about the market.

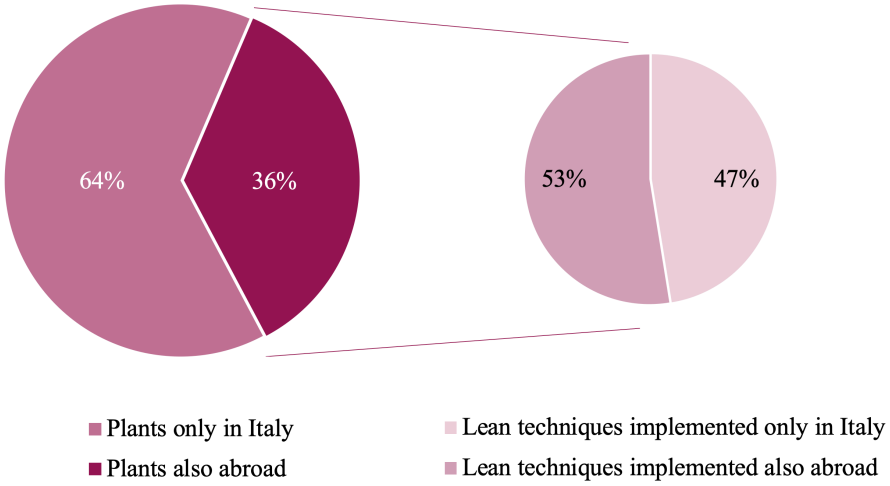
Firstly, a distinction between exporters and non-exporters has been considered in *Graph 30*. It shows a slight difference in the percentage of exporters between Lean firms and Outsiders, percentage which amounts to 96% and 89% respectively.

Graph 30: Export [n^L=197; n^O=214; n^S=411].



Considering the sample limited to Lean firms, *Graph 31* shows that 64% of companies do not have any plant abroad. To some extent, this result was predictable because the Italian manufacturing system is characterized mainly by small and medium enterprises. The remaining 36% – which has plants also abroad – is divided as follows: 19% of the companies implement Lean techniques also in foreign plants while 17%, despite the presence of some plants in foreign countries, decide to restrict Lean implementation only to Italy. Indeed, although successfully implemented in the headquarter, managers often face various difficulties in transferring Lean concepts and practices also to foreign plants (Netland and Aspelund, 2014): this is not so an easy task because companies have to deal with some problems identified by Danese et al. (2017) as the resistance to change, the poor participation and involvement of workers, the additional resource allocation and the strict monitoring of transfer process and outcomes. Additionally, as emphasized by Maritan and Brush (2003), "it is important to have the right organizational structure, train the right people and transfer experienced personnel to assist with the transfer".

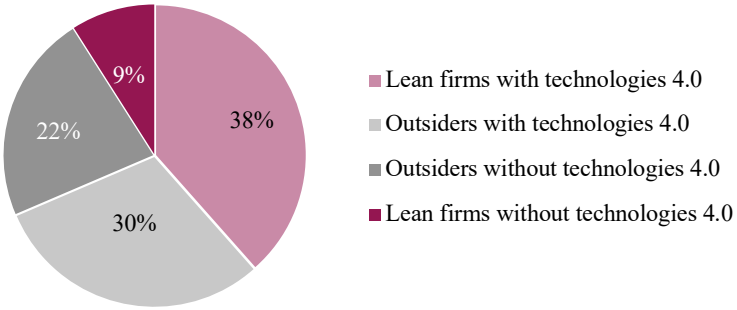
Graph 31: Establishment of plants abroad and the Lean decisions [n^L=220].



Part III: Lean and Industry 4.0

The phenomenon of Industry 4.0 is now discussed adopting a different perspective, the one which compares Lean firms and Outsiders. From *Graph 32* it is possible to understand that, among firms which adopt technologies 4.0, there are more Lean firms (38%) compared to Outsiders (30%). At the same time, taking into account firms which do not implement any technology 4.0, Outsiders (22%) are more than double compared to Lean companies (9%). This leads to think about a sort of positive correlation between Lean and Industry 4.0, as witnessed for instance by Sanders et al. (2016) who find out that "by embracing Industry 4.0, industries are capable of becoming lean without the need to maintain conscious and persistent striving-for-lean efforts".

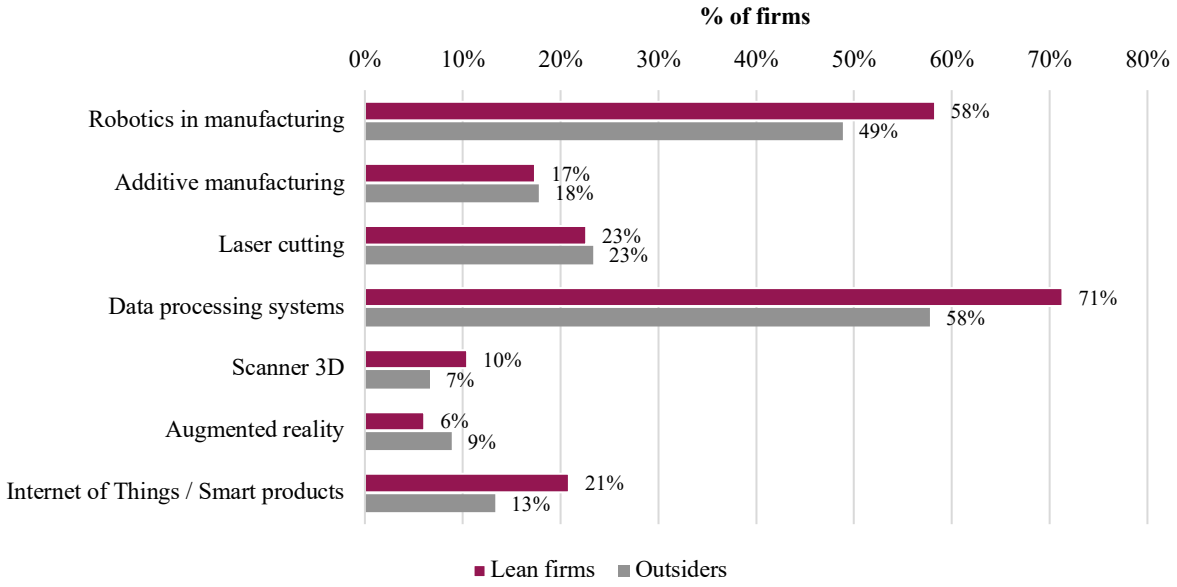
Graph 32: Industry 4.0 between Lean firms and Outsiders [n^L=142; n^O=157].



For sure, the 38% of Lean companies which adopt technologies 4.0 have a different degree of intensity in their implementation within the company, which can be tested from two different perspectives. On one side, taking a look at the percentage of Lean firms which implement each technology 4.0 – on the total number of Lean firms with technologies 4.0 –, *Graph 33* shows that data processing systems (71%) and robotics in manufacturing (58%) are at the top.

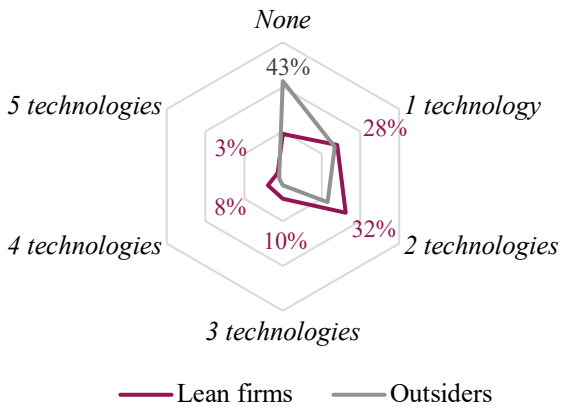
Moreover, looking at the same Graph, it is possible to note a similar distribution of technologies adopted between Lean firms and Outsiders.

Graph 33: Diffusion of technologies 4.0 [n^L=115; n^O=90].



Nevertheless, on the other side, *Graph 34* highlights an important difference between Lean firms and Outsiders: 60% of Lean firms adopt one or two technologies 4.0 while a large part of Outsiders (43%) do not apply any technology and this further confirms that Lean firms could be more inclined to invest in Industry 4.0 compared to Outsiders.

Graph 34*:* Number of technologies 4.0 adopted [n^L=142; n^O=157].

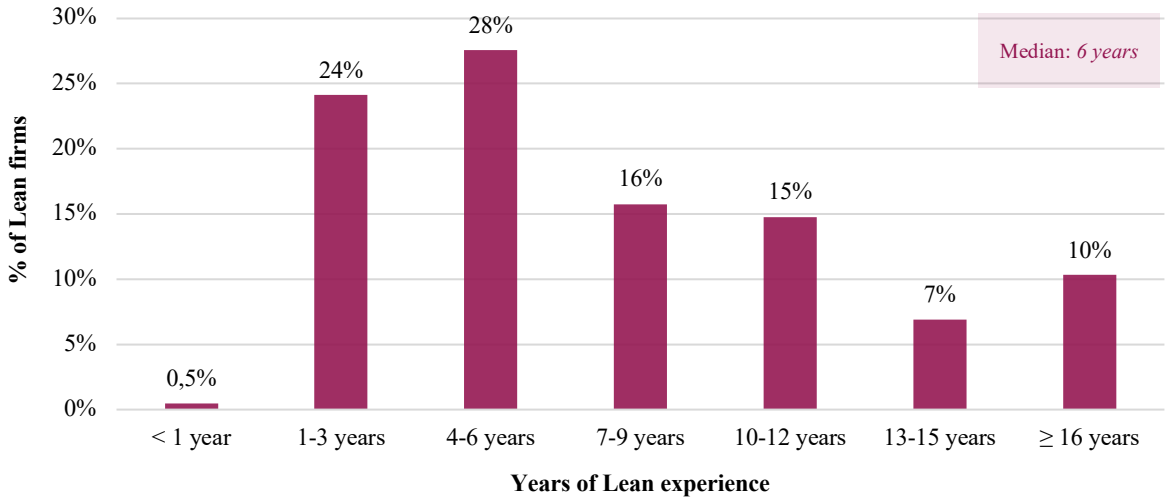


Part IV: The manufacturing side of Lean

Lean is a relatively recent phenomenon since *Graph 35* shows that as the years of Lean experience increases, the number of firms reduces. 52% of Lean firms declare to adopt Lean

practices from one to six years, while for a larger timespan the percentage of firms drastically reduces. Only 10% of the companies are Lean for more than 16 years. Moreover, the distribution of Lean experience years shows that the median year of adoption is 2013. Even if there is not a steady stream of evidence about it, these results can lead to think that a moment of economic stress – which found its peak in 2009 – could spur businesses in getting started with Lean management. Some years later, Salles et al. (2011) demonstrated that in the current economic scenario, companies which do not apply the Lean approach or the ones which do not apply it consistently have great difficulty to obtain over average outcomes. Additionally, according to the same authors, "the current economic crisis has not led to a brake but rather the contrary, a momentum of special interest in the well-known methodology, as the way in which it seems to help the companies in difficulties to improve their performance".

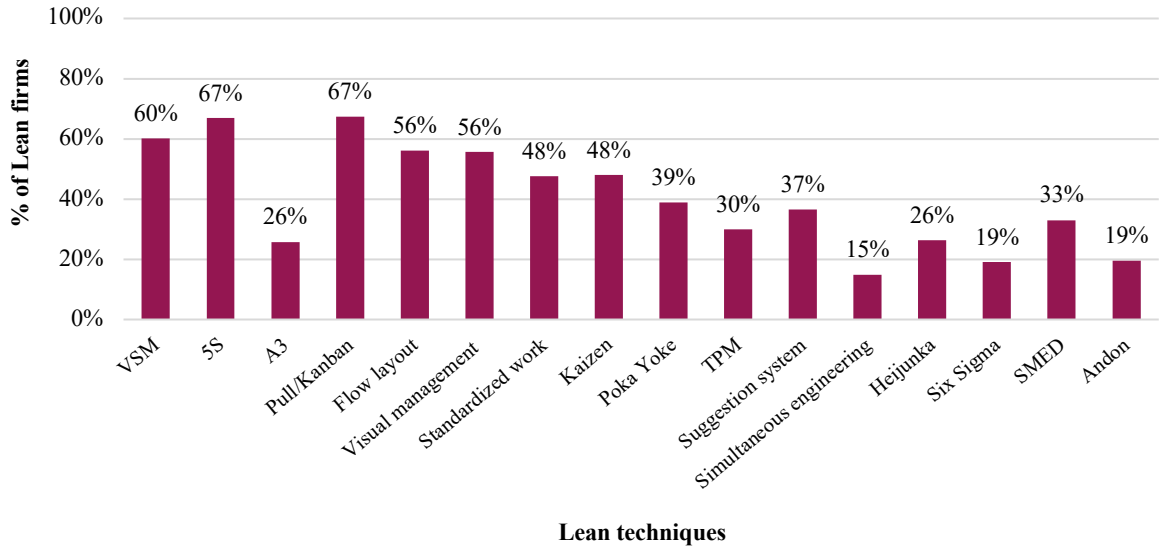
***Graph 35**:* Distribution of Lean companies by years of Lean experience[10] [n^L=203].



Obviously, Graph 35 can also be interpreted as from how long companies apply at least one Lean technique. Lean techniques taken into consideration in this paper and the relative percentages of application on total Lean firms are shown in *Graph 36*: Value Stream Mapping (60%), 5S (67%), A3 (26%), pull logic (67%), flow layout (56%), visual management (56%), standardized work (48%), kaizen (48%), poka yoke (39%), Total Productive Maintenance (30%), suggestion system (37%), simultaneous engineering (15%), heijunka (26%), six sigma (19%), Single Minute Exchange of Die (33%) and Andon (19%).

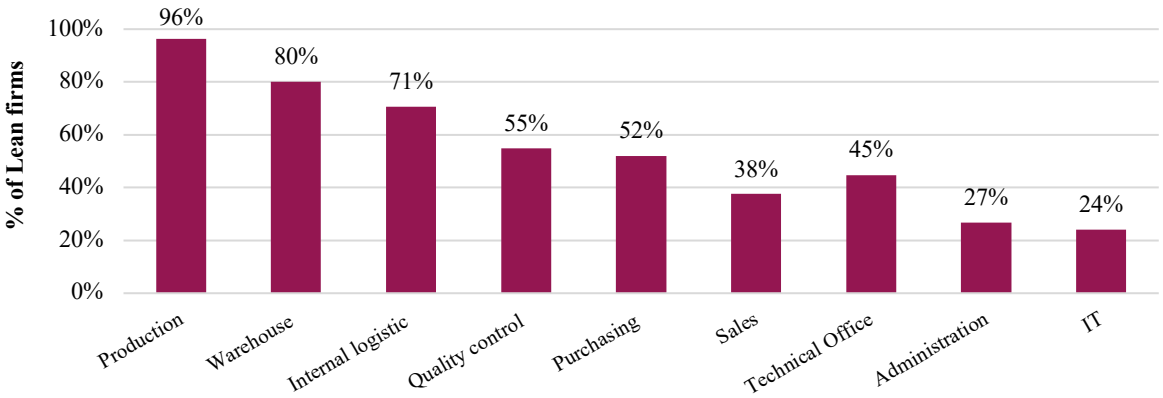
[10] The years of Lean experience have been calculated until 2019.

Graph 36: Lean techniques implementation [n^L=221].



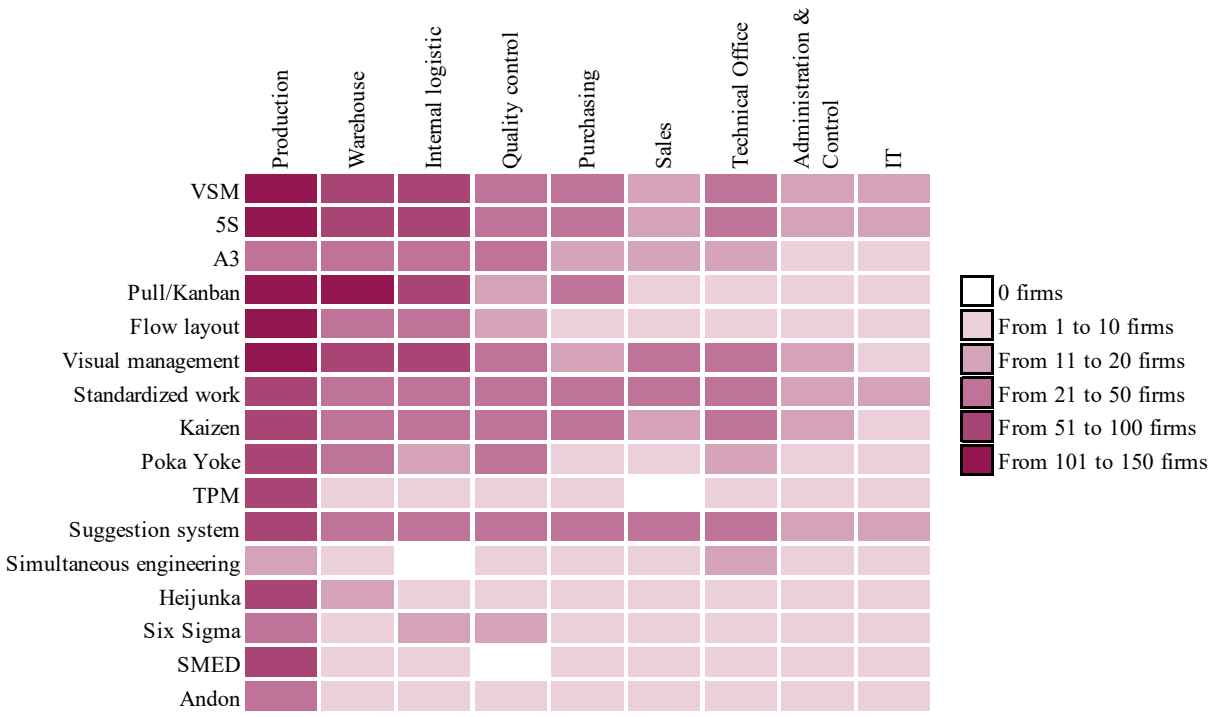
The Lean thinking principle is not confined to the activities that take place in the production function of a firm, rather it spans over different activities performed on different functional areas and ranging from – as an example – warehousing, logistic, quality control, procurement and sales over to administration and control. This kind of information is provided in *Graph 37*. Starting from the business areas in which the largest number of firms apply Lean techniques, they are ordered as follows: production (96%), warehouse (80%), internal logistic (71%), quality control (55%), purchasing (52%), technical office (45%), sales (38%), administration and control (27%) and Information Technology (24%).

Graph 37: Business areas of Lean implementation [n^L=221].



Graph 36 and Graph 37 can be graphically summarized in *Graph 38* which shows the intensity with which each Lean technique is implemented in each business area.

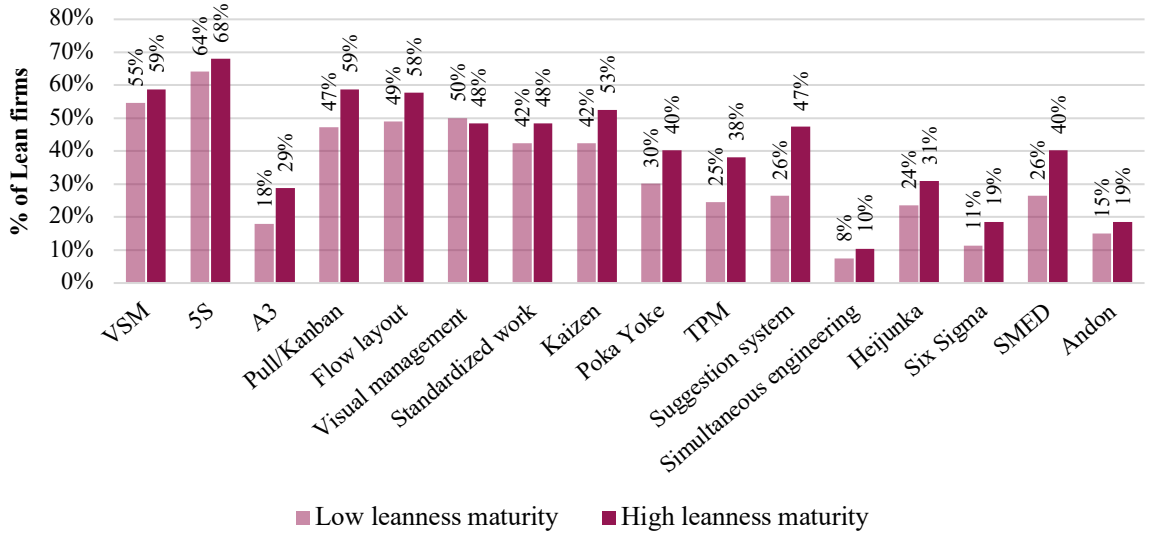
Graph 38: Degree of Lean practices implementation in different business areas [n^L=221].



To conclude the discussion on Lean techniques it can be interesting to make a further investigation about the kind of tools which companies decide to apply first, thus introducing the variable concerned the time. To reach this purpose, Graph 35 can be used to classify companies according to leanness maturity. In particular – as already highlighted – 52% of Lean companies apply Lean tools for a period lower of equal to six years, consequently this could be considered the threshold to distinguish companies characterized by low or high leanness maturity. Specifically, in this paper, "*low leanness maturity*" means that companies apply at least one Lean technique for a period equal or lower than six years while "*high leanness maturity*" means that companies apply at least one Lean technique for a period of at least seven years. The appropriateness of this choice relies on the fact that six years is also the median year of Lean adoption, in addition to the evidence provided by Camuffo and Gerli (2016) who found some differences between two groups of companies identified using a period of Lean experience of five years as threshold.

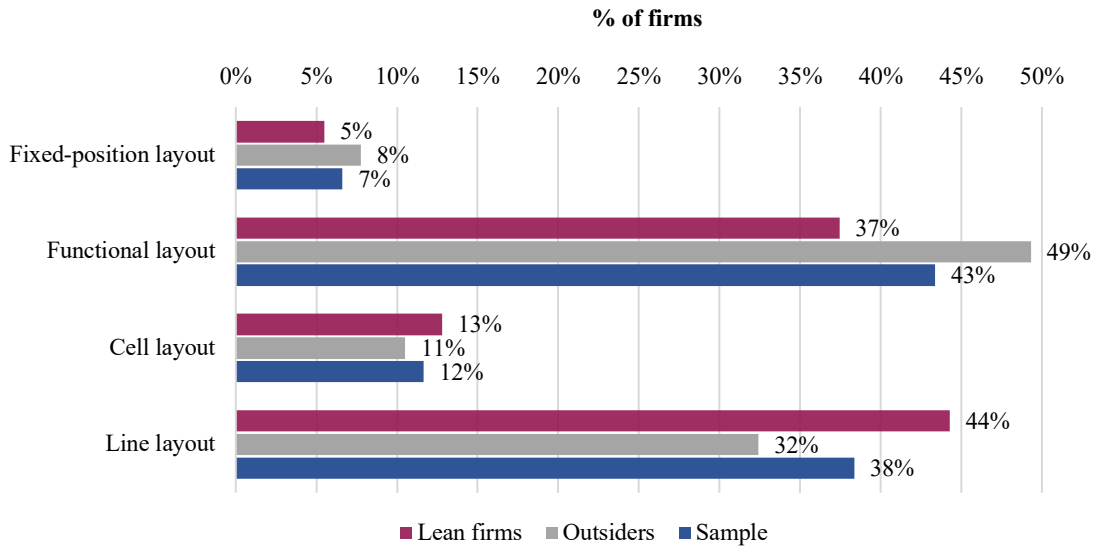
Due to the fact that almost all companies apply Lean techniques in production (96%), for a while the analysis focuses on this business area. What results in *Graph 39* is that there is not a significant difference in the distribution of low and high leanness maturity firms when different types of Lean techniques implemented within the firm are considered. Specifically, with the exception of visual management, it is possible to note a slightly higher percentage of implementation by Lean firms with high leanness maturity compared to the ones with low leanness maturity.

Graph 39: Distribution of Lean firms by Lean techniques applied in production [n^L=203].



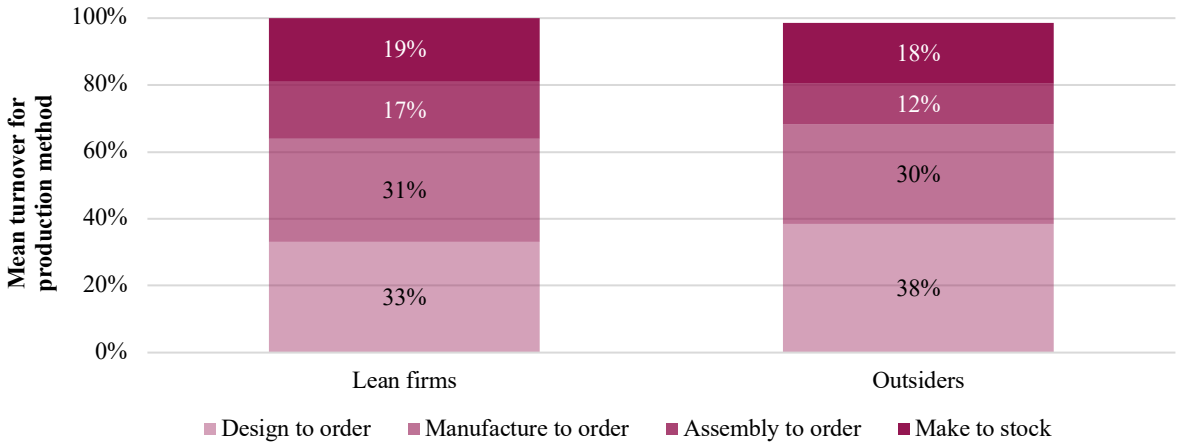
Maintaining the focus on production, there are different alternative ways of organizing it. Generally, functional layout is the conventional layout adopted by companies even if "in recent times, many firms have migrated from a functional type production system to the cellular type to gain competitive advantage" (Pitchuka et al., 2006). Nevertheless, from *Graph 40* it is possible to note that the functional one is still highly spread, but this is simply explained by the fact that the change path takes long time. Functional layout is adopted by 49% of Outsiders while for Lean firms the percentage is lower (37%). In an ideal situation, Lean firms adopt a cell layout in which each cell is a "cluster of machines put together in a unidirectional layout to manufacture a family of parts" (Aulakh and Gill, 2008) and then the outcome of each cell is combined through a line layout. However, as just said, this is only an ideal situation.

Graph 40: Type of layout adopted [n^L=219; n^S=438].



Finally, despite a different approach to the one adopted in Graph 13, in *Graph 41* it is possible to note the mean turnover for each production method for Lean firms and Outsiders. However, it seems that this is not an element which could specifically characterize the two groups of companies, concluding that Lean firms do not tend to prefer some production methods different from the ones of the Outsiders.

Graph 41: Average revenues related to different production approaches [n^L=203; n^O=209].



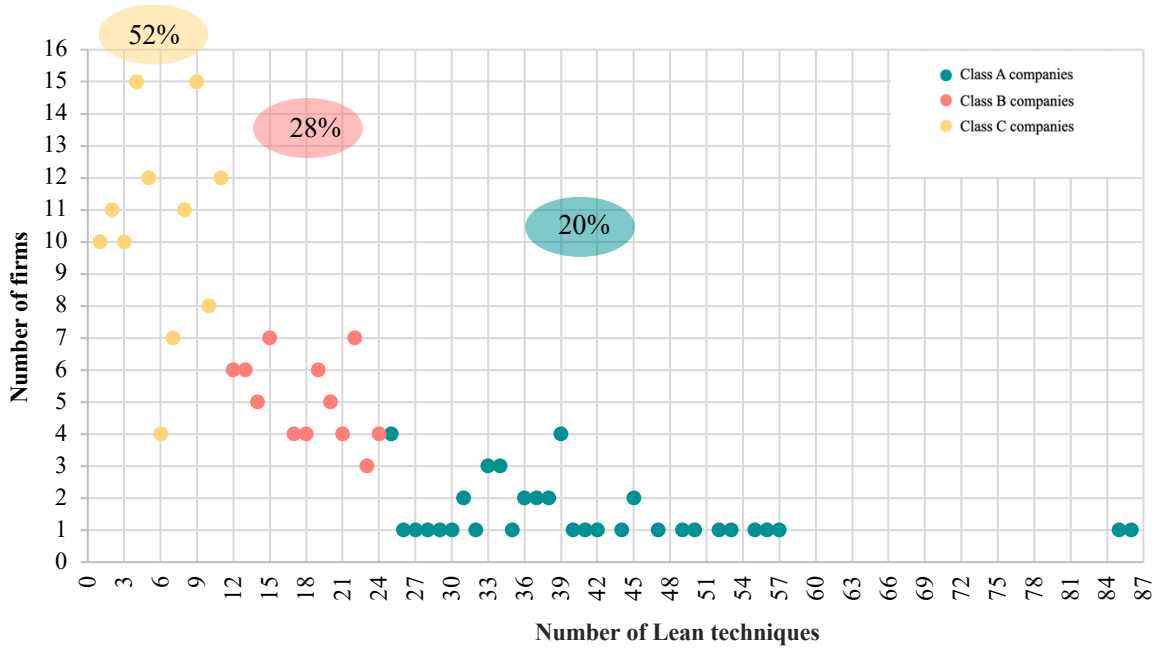
Starting from some graphs to present the whole sample – from Graph 5 to Graph 16 –, the analysis assumed a higher degree of specificity when the distinction between Lean firms and Outsiders has been introduced. However, this is not yet the heart of the analysis: it will be introduced in the next paragraph when Lean firms will be further splitted into Beginner and Advanced firms characterized by different levels of leanness maturity.

3.3. Beginner, Advanced, Outsider firms and their related leanness maturity

To approach the core of this research, Lean companies have been clustered – firstly – according to their leanness intensity, thus identifying Beginner and Advanced firms. The procedure adopted to differentiate Lean firms in Beginners and Advanced is the Pareto 80/20 law and its refinement into A, B and C classes: "the *A* group, consisting of approximately 20% of the items, accounts for 80% of the phenomenon; the *B* group, i.e. the next 30% of the items, accounts for 10% of the phenomenon, and the *C* group, which contains 50% of the items, accounts for only 10% of the phenomenon" (Grosfeld-Nir et al., 2007).

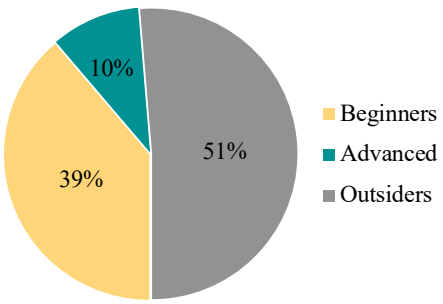
For this purpose, *Graph 42* shows the distribution of firms according to the number of Lean techniques implemented, in which class A is in green, class B in pink and class C in yellow. The repartition of the sample is better presented in *Appendix B*.

Graph 42: Distribution of Lean companies by leanness intensity [n^L=221].



Graph 42 highlights a detailed classification of companies among classes A, B and C. However, in light of the elaborations presented here below, a significant difference between companies of class B and class C has not been found. This is the reason why this research classifies Lean companies between *Advanced* – the ones which are part of class A – and *Beginners* – the ones which are part of both class B and class C. Companies with a high leanness intensity level – thus, the Advanced companies – and companies with a medium-low leanness intensity level – thus, the Beginner ones – will be always compared to the *Outsiders* in order to better capture the differences. The result is that 39%, 10% and 51% of the companies have been considered Beginner, Advanced and Outsider companies, respectively – *Graph 43*.

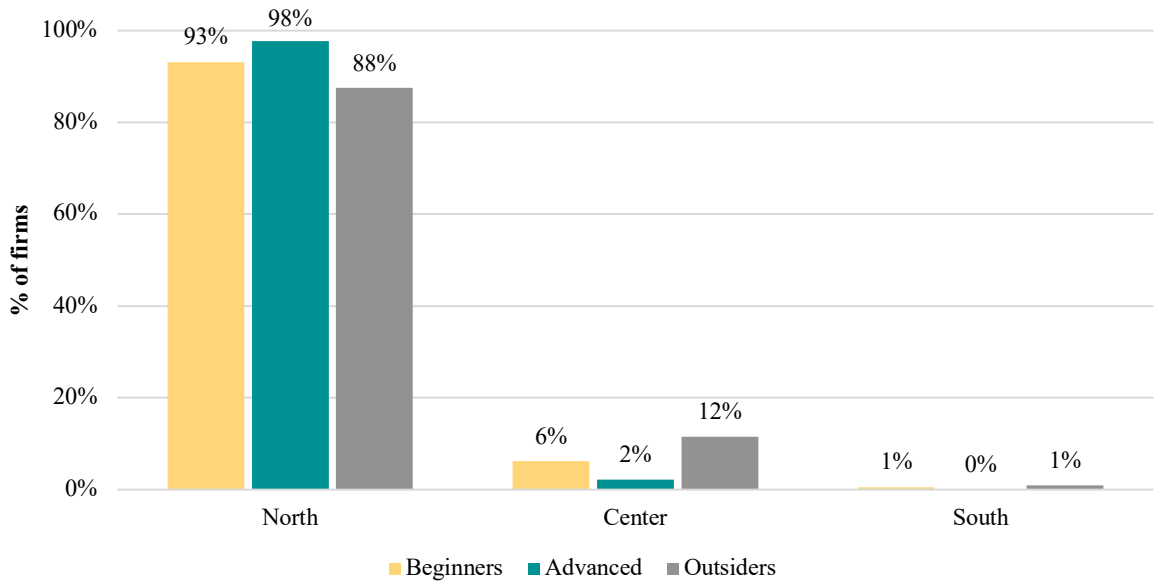
Graph 43: Beginner, Advanced and Outsider firms [n^B=176; n^A=45; n^O=233][11].



[11] n^B refers to the number of Beginner firms: the sample includes 115 Beginner firms, of which 114 have provided information to make a classification according to leanness maturity.
n^A refers to the number of Advanced firms: the sample includes 45 Advanced firms, of which 43 have provided information to make a classification according to leanness maturity.

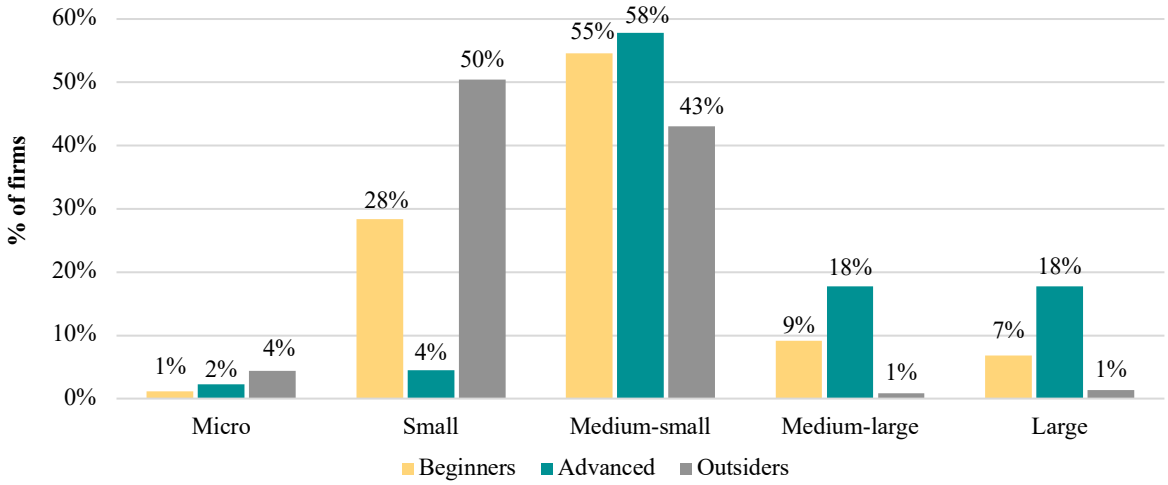
As made before to present the sample, also in this case a short introduction of the companies is provided, starting from the distribution by geographical location in *Graph 44*. The North of Italy is where the majority of Beginner (93%), Advanced (98%) and Outsider (88%) companies are established. However, while Beginner and Advanced companies are almost absent in the Center and even more in the South of Italy, 12% of Outsiders are established in the Center meaning that – probably – companies placed in the North of Italy are more likely to adopt a Lean approach.

Graph 44: Distribution by geographical location [n^B=176; n^A=45; n^O=233].



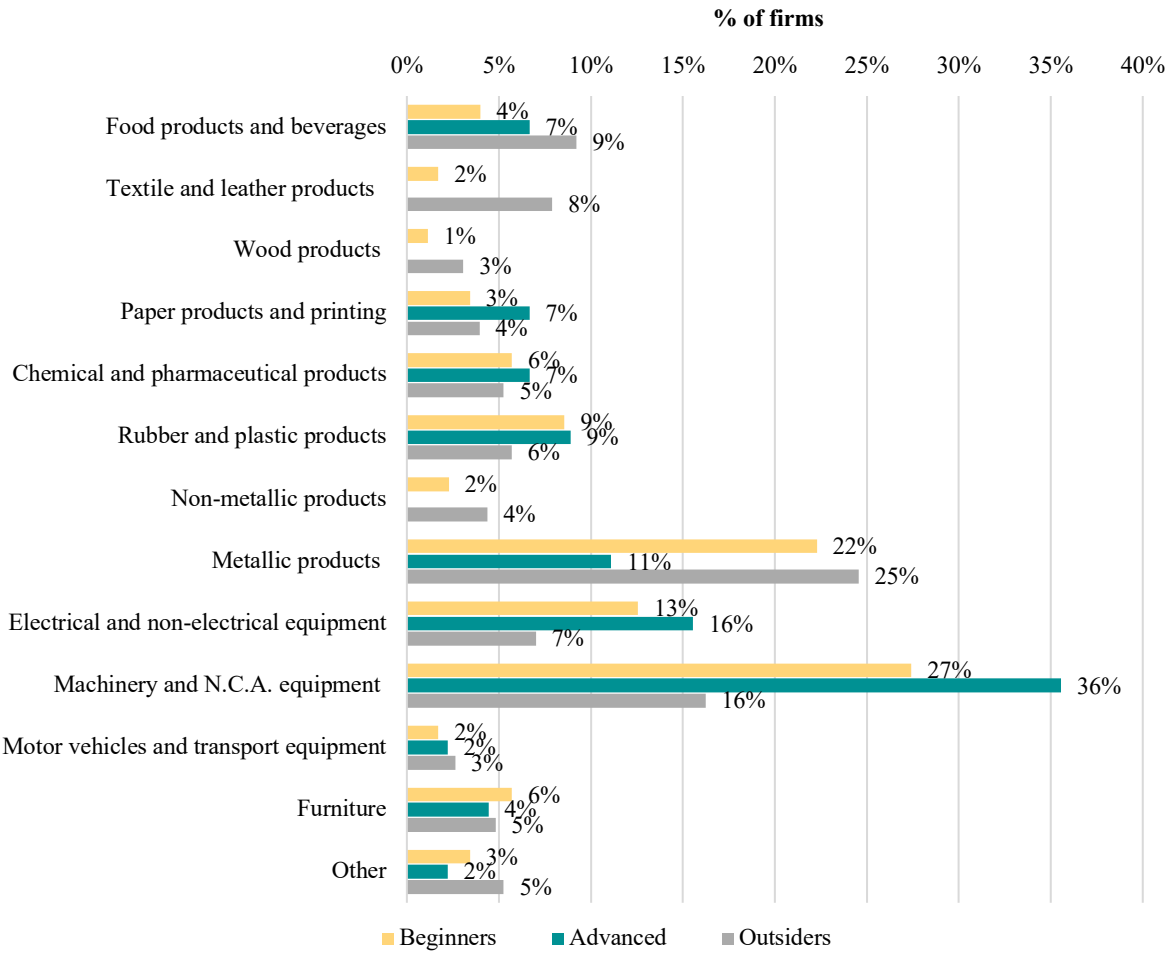
In *Graph 45* it is possible to note the different distribution between Beginner and Advanced companies in terms of size. Applying the same criteria above described, it results that both Beginner and Advanced companies are mainly of medium-small size, which account for 55% and 58%, respectively. However, excluding the medium-small range, the remaining companies are differently distributed: while Beginners tend to focus on small size (28%), Advanced companies tend to be of larger dimension. This is in line with Bevilacqua et al. (2017), whose research suggests that "[Advanced] companies are characterized by a greater number of employees and a larger turnover" compared to Beginners, explaining these results with a higher suitability of complex Lean practices for large companies with enough resources.

Graph 45: Distribution by companies size [n^B=176; n^A=45; n^O=230].



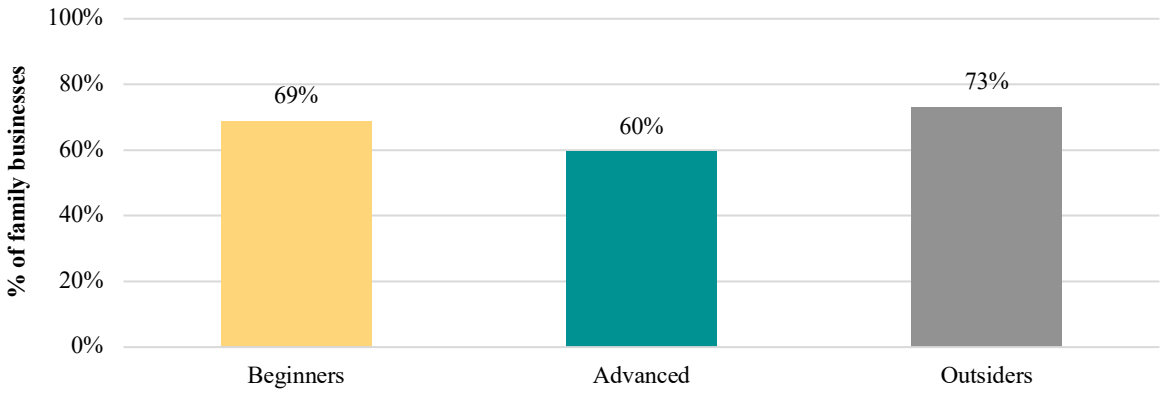
For what concerns the industry in which companies operate, in *Graph 46* there is a significant presence of Advanced companies in the machinery and N.C.A. equipment (36%) while the remaining companies are distributed – to some extent – equally within the other sectors. On the other side, Beginners focus mainly on machinery and N.C.A. equipment (27%) but also on the metallurgical sector (22%).

Graph 46: Distribution by sector [n^B=175; n^A=45; n^O=228].



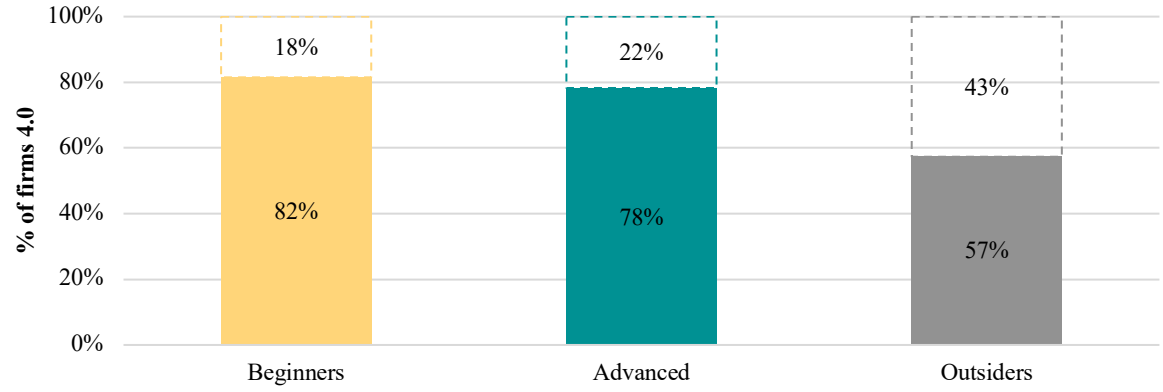
Changing the focus of the analysis and focusing on the type of governance, *Graph 47* highlights that more than the half of Beginners (69%), Advanced (60%) and Outsiders (73%) are family businesses.

Graph 47: Family businesses [n^B=173; n^A=42; n^O=227].



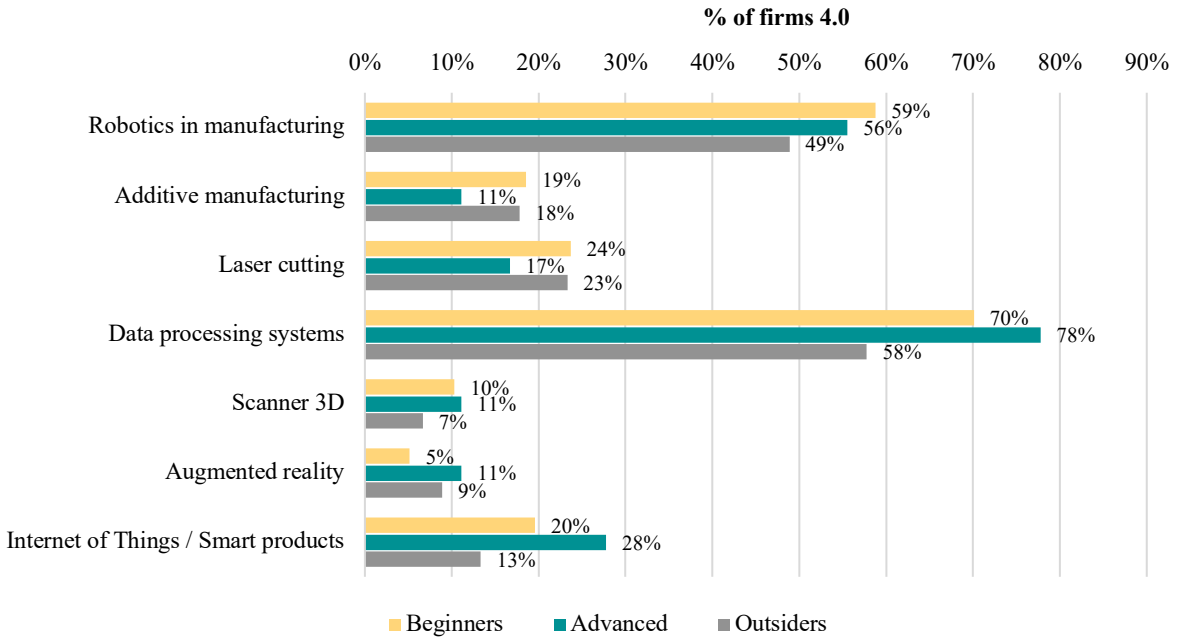
Conversely, *Graph 48* introduces some considerations about the relationship between leanness intensity and Industry 4.0, showing that both Beginners and Advanced have percentages similar between them but larger between them and Outsiders in the involvement on Industry 4.0. Thus, in light of the evidence reached until now, it is possible to confirm the previously hypothesized positive correlation between Lean and Industry 4.0, but it is not possible to state that the intensity of Lean impacts on the decisions to implement technologies 4.0.

Graph 48: Industry 4.0 [n^B=119; n^A=23; n^O=157].



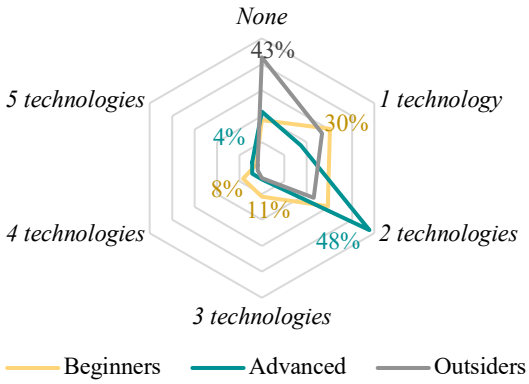
From another perspective, in *Graph 49* there is a visual representation about the diffusion of each technology 4.0. The conclusions are similar to the ones already reached indeed, another time, data processing systems and robotics in manufacturing are the most spread technologies.

Graph 49: Diffusion of technologies 4.0 [n^B=97; n^A=18; n^O=90].



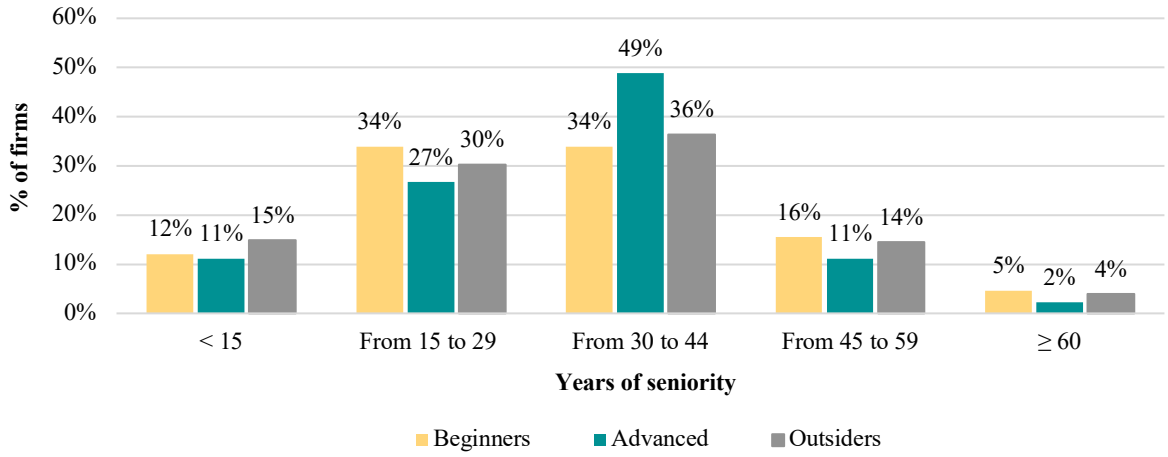
The situation is quite different when the distribution of firms according to the number of technologies 4.0 implemented is considered – *Graph 50*. Analyzing the same phenomenon from different perspectives is a way to capture every shade possible, as in this case in which a difference between Beginners and Advanced has been found. In particular, Beginners mainly apply one technology (30%), Advanced companies mainly apply two technologies simultaneously (48%) while Outsiders tend to not rely on Industry 4.0. This kind of analysis allows to identify another interesting field of investigation for what concerns the Lean world, but this is not the purpose of this paper.

Graph 50: Number of technologies 4.0 adopted [n^B=119; n^A=23; n^O=157].



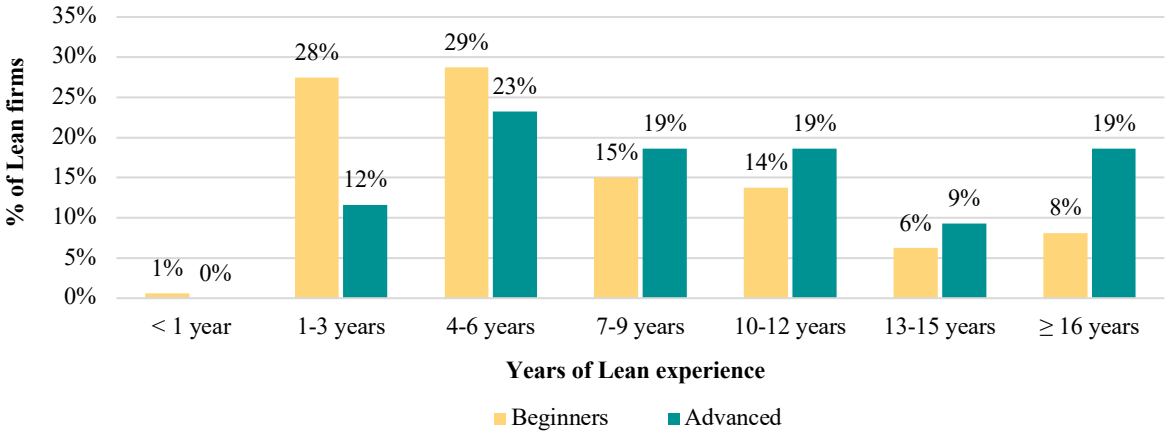
Remaining focused on the core of this research, now this paper investigates the seniority of firms, finding – from *Graph 51* – that the majority of both Beginner and Advanced companies have from 15 to 44 years of seniority.

Graph 51: Seniority of firms [n^B=174; n^A=45; n^O=228].



Even if the majority of firms were born from 15 to 44 years ago, the experience with Lean is more recent. Specifically, the Beginner company which first implemented Lean has started to adopt it in 1996 while for Advanced companies this data is 1986. Looking at *Graph 52* it is possible to notice that the trend followed by Beginner and Advanced companies is different: as the years of Lean experience increase, the number of Advanced companies tends to remain stable while the number of Beginners reduces. This could lead to hypothesize a potential relationship between leanness intensity and leanness maturity, even if this assumption will be better explored later.

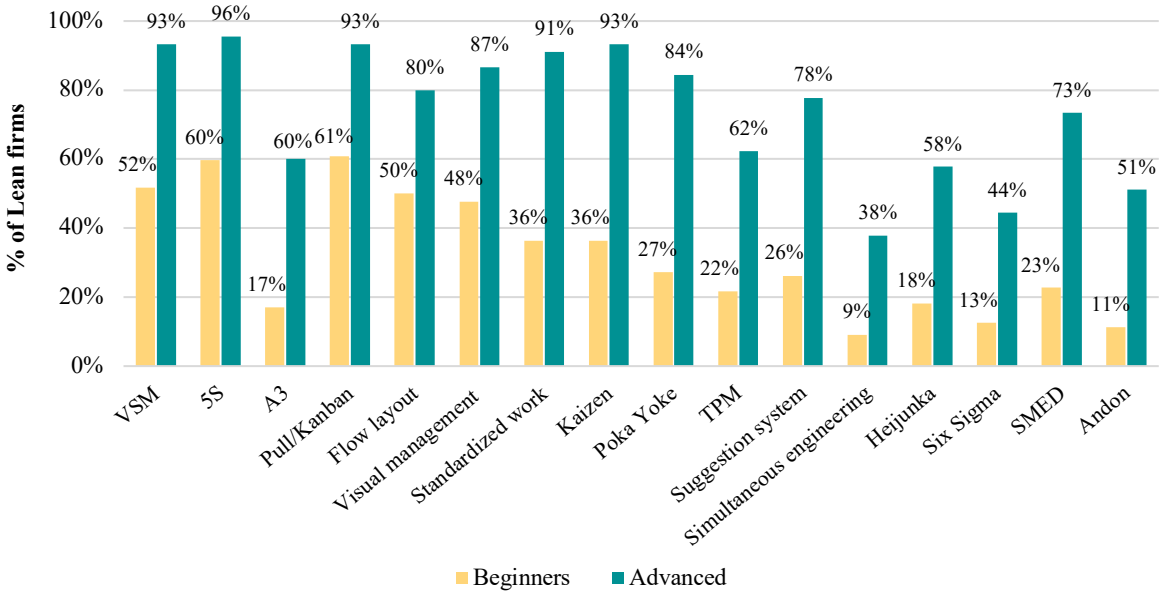
Graph 52: Distribution of Lean companies by years of Lean experience [n^B=160; n^A=43].



Speaking about the years of Lean experience, the next step is about a discussion on techniques adopted by Lean firms. Looking at *Graph 53* it is necessary to avoid the pitfall of comparing Beginner and Advanced companies: this would not make sense because Advanced companies, naturally, implement a larger number of techniques. The aim of Graph 53 and its right interpretation are the understanding of the most widespread techniques by each group of companies. For Advanced companies, the result is that VSM (93%), 5S (96%), pull logic (93%),

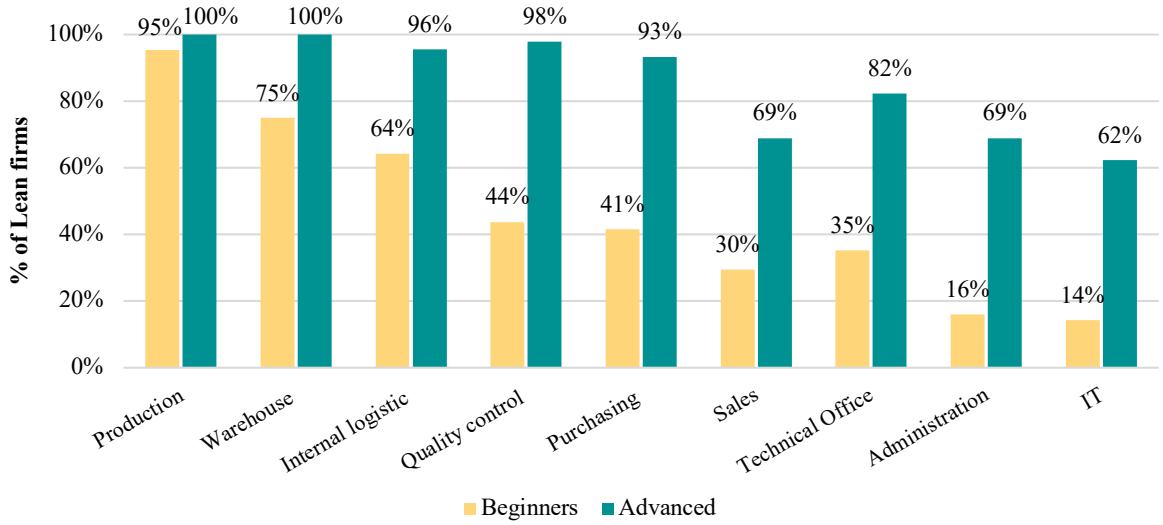
standardized work (91%) and kaizen (93%) are implemented by more than 90% of the companies. While for Beginners the threshold is lower and the techniques most implemented are the same – to some extent – of the ones of Advanced companies: pull logic (61%), 5S (60%) and VSM (52%).

Graph 53: Lean techniques implementation [n^B=176; n^A=45].



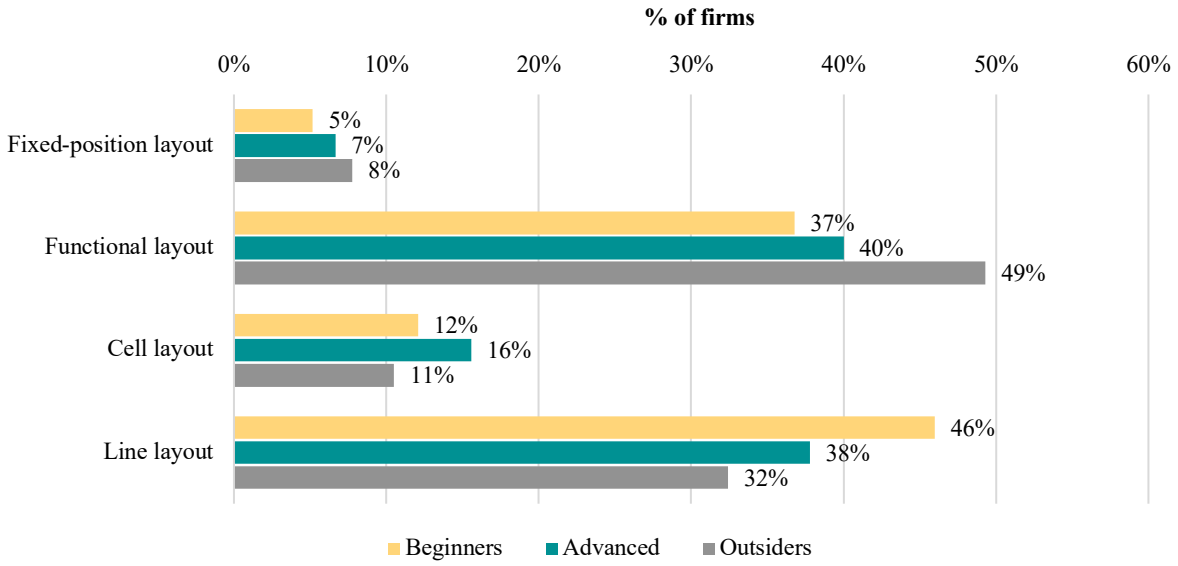
All techniques just mentioned find their application in different business areas – *Graph 54*. While in production almost all Beginners (95%) and all Advanced companies (100%) implement at least one technique, in the other business areas the difference between Beginners and Advanced becomes larger.

Graph 54: Business areas of Lean implementation [n^B=176; n^A=45].



Lastly, also the layout adopted by companies has been deepened according to the level of leanness intensity – *Graph 55*. The discussion previously made in Graph 40 highlighted the adoption of a cell layout as an ideal situation. This because, as pointed out by Joseph (2006), Lean work cells provide important operational benefits including: reducing lead times; minimizing handling distances/walking; improving visual management, inventory management and communications among workers; reducing work in progress; decreasing use of space. Cell layout is adopted by 16% of Advanced, 12% of Beginners and 11% of Outsiders: the difference between Advanced and Beginners is minimal so that it is not possible to assert the greater awareness by Advanced companies in speaking about the layout choice.

Graph 55: Type of layout adopted [n^B=174; n^A=45; n^O=219].



The sample has been broadly discussed until now and consequently it is possible to turn the focus on the economic and financial side of Lean, applying the criteria of leanness intensity and leanness maturity to capture the differences.

3.4. Data analysis: the initial economic and financial results

Lean tools here above described, together with principles implemented, actions undertaken and changes made, are all elements exploited by a company to enhance its performance and achieve the desired economic and financial goals. Thus, this paragraph aims to find whether a Lean production system really relates to better economic and financial performances over time. The performance can be translated into a measurable format through the use of some indicators such as: EBITDA-to-sales, value-added per capita, leverage, return on assets, return on equity, return

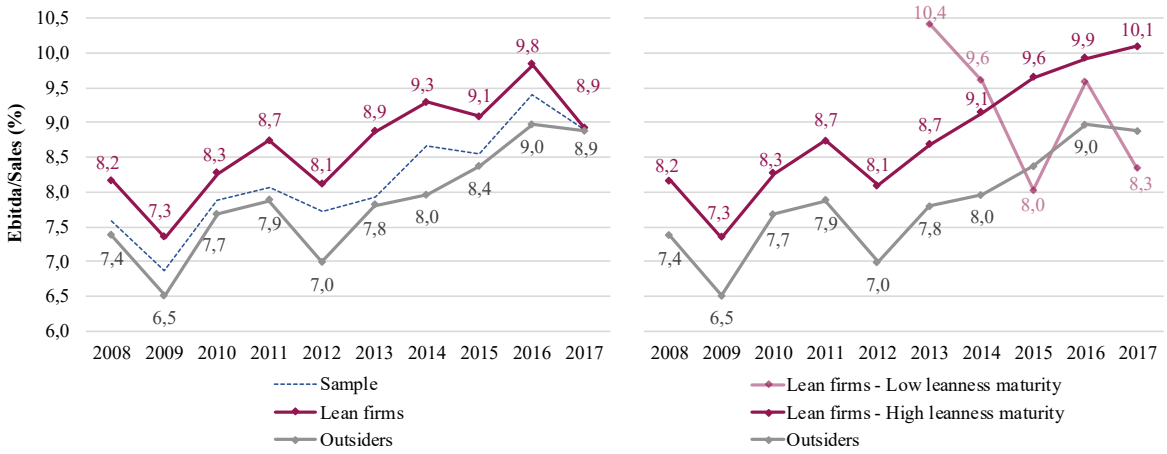
on investment, return on sales, revenues and CAGR on revenues. Moreover, in their analysis, the median values of each year have been considered.

To make as reliable as possible this analysis, a meticulous elaboration of the economic and financial indexes for the sample of Lean firms has been made. Precisely, the database allows to track the performance of companies from 2008 to 2017 but this does not mean that necessarily a company became Lean before 2008 – indeed 63 out of 221 Lean companies became Lean before 2008. Consequently, considering the sample of the same size for all the ten years – thus, considering all companies regardless when they became Lean – could lead to misleading results. To avoid this problem, the value of each index for each year has been calculated considering only those companies which were already Lean in that specific year. To clarify the type of elaboration made on data available, an example will follow: assuming that "company A" implemented the first Lean technique in 2012, the economic and financial indexes have been considered only for the period 2012-2017 and not for the period 2008-2011.

In this first part of the economic and financial elaborations – meaning from Graph 56 to Graph 61 – the graphs are divided in two parts. In the left-graph there is a comparison between Lean and Outsider firms while in the right-graph there is a comparison between Lean firms characterized by low and high leanness maturity.

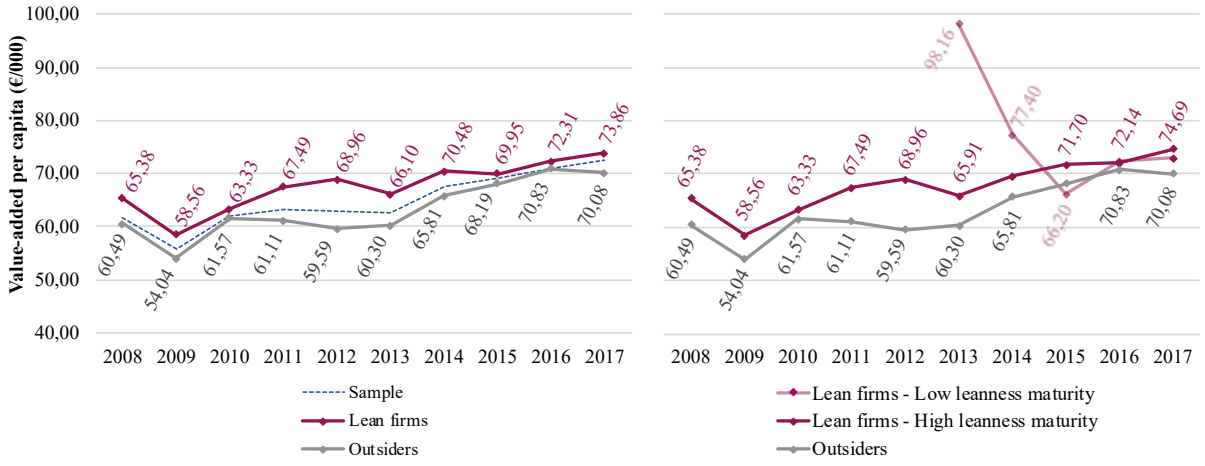
After this premise, it is possible to move on looking at the first index: EBITDA-to-sales in *Graph 56*. EBITDA stands for Earning Before Interests Taxes Depreciation and Amortization: it indicates to potential investors the company's ability to generate income considering only the core business. When EBITDA is related with sales, the resulting ratio allows to assess the company profitability. However, being profitability highly influenced by the industry in which the company operates, there are not absolute optimal values. More than discussing about the values of each index, in this circumstance it is more valuable to capture the differences among the groups of companies. Looking at Lean firms in Graph 56, they always perform better than Outsiders even if from 2016 to 2017 a decline by Lean companies led to a convergence with Outsiders. Breaking down Lean firms into low and high leanness maturity, a difference arises: while for high maturity companies the EBITDA-to-sales ratio continually increases over time, for low maturity companies the trend is not homogeneous, meaning that the experience with Lean matters. Focusing on low leanness maturity, in the first years of Lean, companies sustain a lot of costs and so one can expect a worsening of the indexes. This is what really occurs, but in 2013 – the year considered as the threshold to differentiate low and high leanness maturity firms – the ratio is higher compared to high maturity firms: this could mean that probably, before starting with Lean, low maturity companies performed even better.

Graph 56: EBITDA-to-sales [n^L=180; n^O=198].



Value-added per capita is an outstanding measure of the extent to which the company exploits the employee's strengths. Also in *Graph 57* Lean firms perform better than Outsiders but in this case the difference between them is lower compared to Graph 56. Additionally, for low maturity firms, after having started with Lean, the companies experienced a significant reduction of the value-added per capita over time, even if since 2015 there has been a recovery.

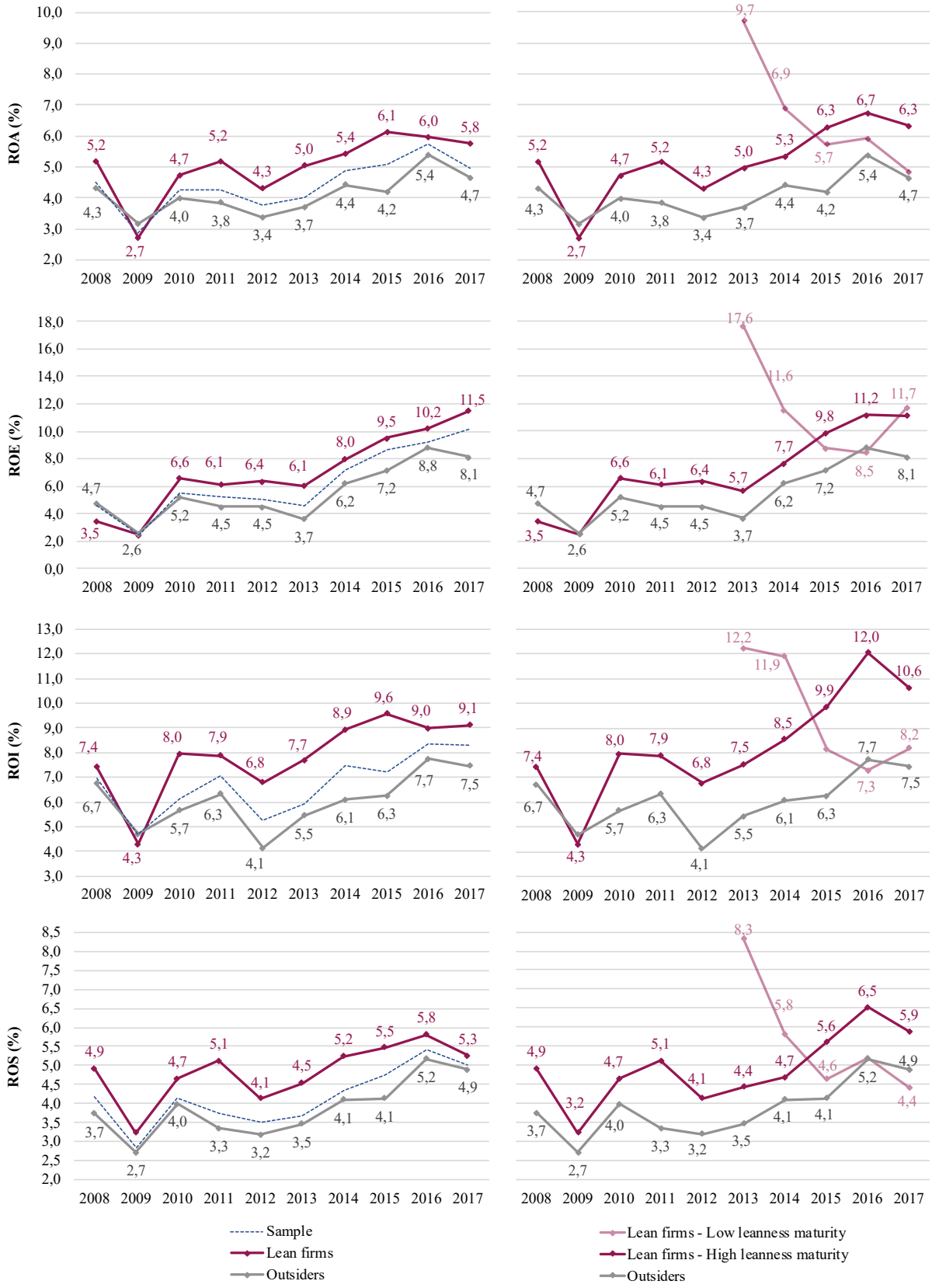
Graph 57: Value-added per capita in €/000[12] [n^L=180; n^O=198].



Just below four profitability indexes will be considered for evaluating the financial performance: ROA, ROE, ROI and ROS – *Graph 58*. They will be considered simultaneously because they are highly correlated and so they behave similarly. It is possible to note a negative peak for both Lean firms and Outsiders in 2009, a behavior likely due to the economic crisis. Considering high maturity companies, it seems that the worsening of the indexes in 2009 is greater for them compared to Outsiders, even if after that there has been a recovery. Conversely, low maturity firms suffer a drastic worsening of their returns when they approach to Lean.

[12] Value-added per capita is calculated as value-added divided by the number of employees.

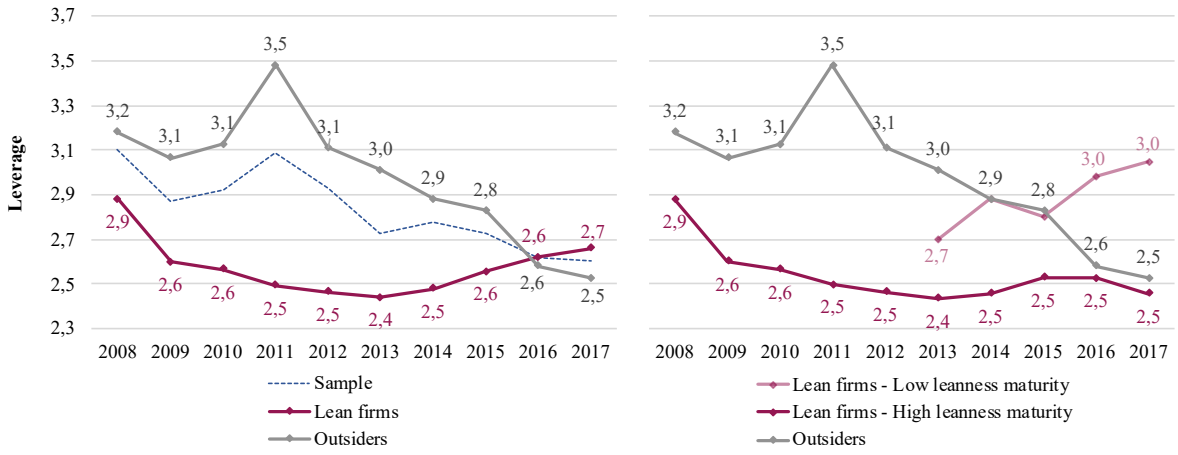
Graph 58: ROA, ROE, ROI, ROS[13] [n^L=180; n^O=198].



[13] ROA is calculated as EBIT divided by total assets; ROE is calculated as net income divided by shareholders' equity; ROI is calculated as EBIT divided by operating net invested capital; ROS is calculated as EBIT divided by sales.

Now the leverage is considered. Leverage is a measure of the company's indebtedness and consequently the lower its value, the better. In *Graph 59* Lean companies are placed below Outsiders with the exception of the last years in which it seems that the median leverage of Outsiders continually decreases while the median leverage of Lean companies increases. In case of distinction between low and high maturity, it is expected to find a greater leverage for low maturity firms because, as already stated, there is a high incidence of costs in the first years of Lean: this is exactly confirmed by the Graph.

Graph 59: Leverage[14] [n^L=180; n^O=198].



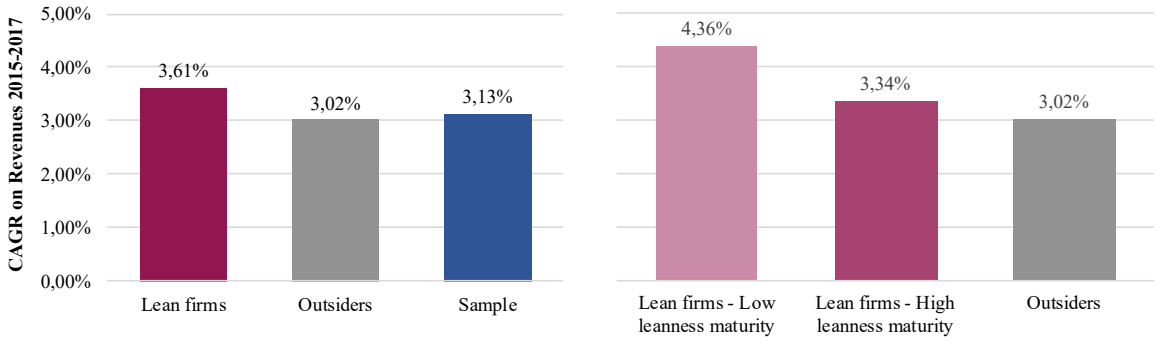
Finally, also the median revenues have been considered. However, what *Graph 60* says is that Lean firms – both low and high maturity companies – have consistently greater revenues compared to Outsiders, thus simply it provides information on the size of companies.

Graph 60: Revenues in €/000.000 [n^L=180; n^O=198].

[14] Leverage is calculated as total assets divided by equity.

Consequently, more than the analysis of revenues, which does not provide so relevant information, it is meaningful focusing the attention on Compound Annual Growth Rate – CAGR – which measures the mean annual growth rate over a certain period of time. Specifically, in *Graph 61* it has been calculated on revenues of 2015-2017: Lean firms (3,61%) have a greater CAGR compared to Outsiders (3,02%) and Lean firms with low leanness maturity (4,36%) have a greater CAGR compared to the ones with high maturity (3,34%).

Graph 61: CAGR on revenues 2015-2017[15] [n^L=180 ; n^O=198].



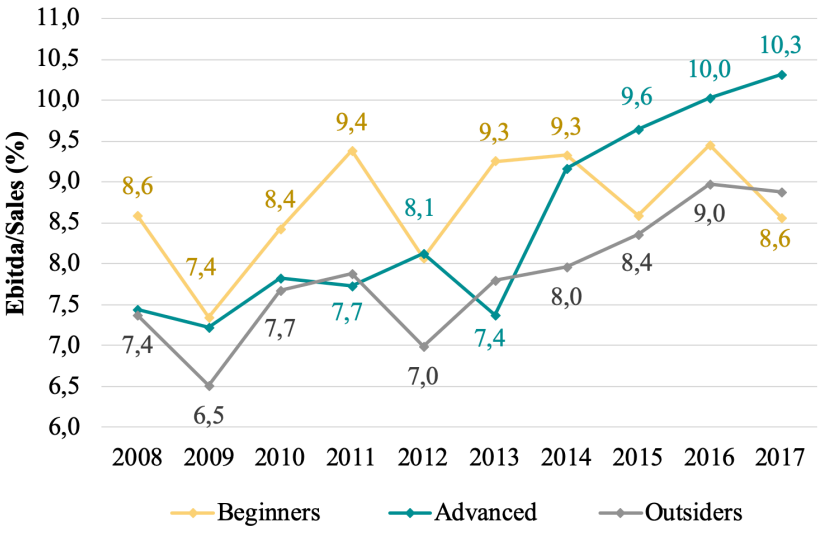
The comparisons between Lean firms and Outsiders and the subsequent distinction between low and high leanness maturity are not enough. A further deeper level in this investigation consists in breaking down the sample of Lean firms into Beginners and Advanced for understanding their different trends related to economic and financial indexes. From Graph 62 to Graph 67, each index has been analyzed from two different perspectives. On one side, – in the left graph – it is possible to notice the trend of each index over time making a distinction between Beginner and Advanced companies and considering, as made before, the median values. On the other side, – in the right table – it is simultaneously provided a table aimed to understand the mean difference over the last three years when the distinction between Beginner and Advanced companies, and between low and high leanness maturity have been considered.

Also in this case, the economic and financial analysis starts with EBITDA-to-sales. Looking at *Graph 62* it is not possible to find a significant difference between Beginners and Advanced but, rather, until 2014 Beginners performed better than Advanced companies. Advanced companies started to grow from 2013 and this growth has continued so that in 2014 EBITDA-to-sales became greater compared to Beginners. Conversely, the growth of Beginners in 2014 stopped. In terms of maturity – considering the mean of the last three years – Outsiders (8,7%) have a lower percentage compared to the others groups of companies, Beginners with low

[15] CAGR on revenues 2015-2017 is calculated as $\left(\frac{Revenues\ 2017}{Revenues\ 2015}\right)^{\left(\frac{1}{3\ years}\right)} - 1$.

maturity (8,3%) have a lower percentage than the ones with high maturity (9,9%) and lastly Advanced companies with low maturity (10,8%) have a greater percentage than the ones with high maturity (9,9%).

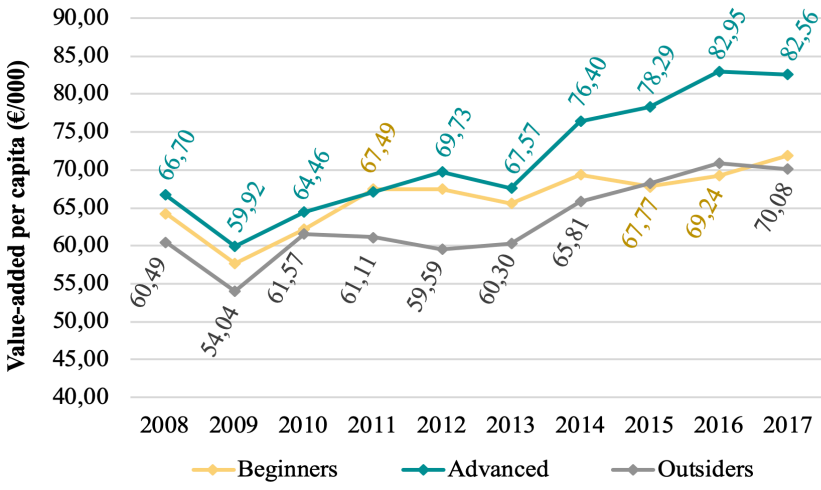
Graph 62: EBITDA-to-sales [n^B=142; n^A=38; n^O=198].



	Leanness maturity	
	Low	*High*
Beginners	8,3%	9,9%
Advanced	10,8%	9,9%
Outsiders	8,7%	

Considering the value-added per capita in *Graph 63*, Advanced companies have a slightly higher value until 2013 and then, after that year, the difference with Beginners started to become larger and larger over time. Additionally, this difference is more related to the growth of Advanced companies rather than to the decrease of Beginners. When considering also the maturity, the situation is similar to the one described for EBITDA-to-sales, meaning that Beginners with low maturity (67,92) have a lower value-added per capita than the ones with high maturity (70,47) while Advanced companies with low maturity (89,57) have a greater value than the ones with high maturity (78,50).

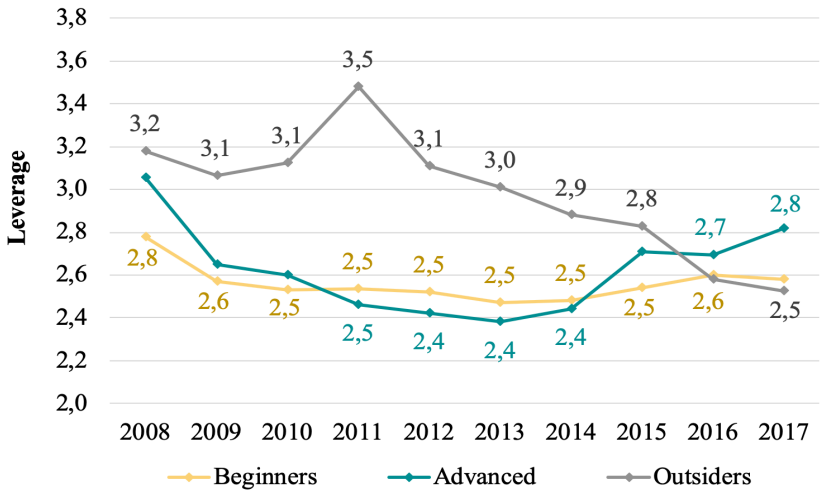
Graph 63: Value-added per capita in €/000 [n^B=142; n^A=38; n^O=198].



	Leanness maturity	
	Low	*High*
Beginners	67,92	70,47
Advanced	89,57	78,50
Outsiders	69,70	

Going on with the analysis, the next index discussed is Leverage – *Graph 64*. Unfortunately, also in this case it is not possible to find a relevant difference between Beginners and Advanced but, rather, from 2014 the situation became worst for Advanced. When the maturity is considered, the best situation is experienced by Beginners with high maturity (2,47).

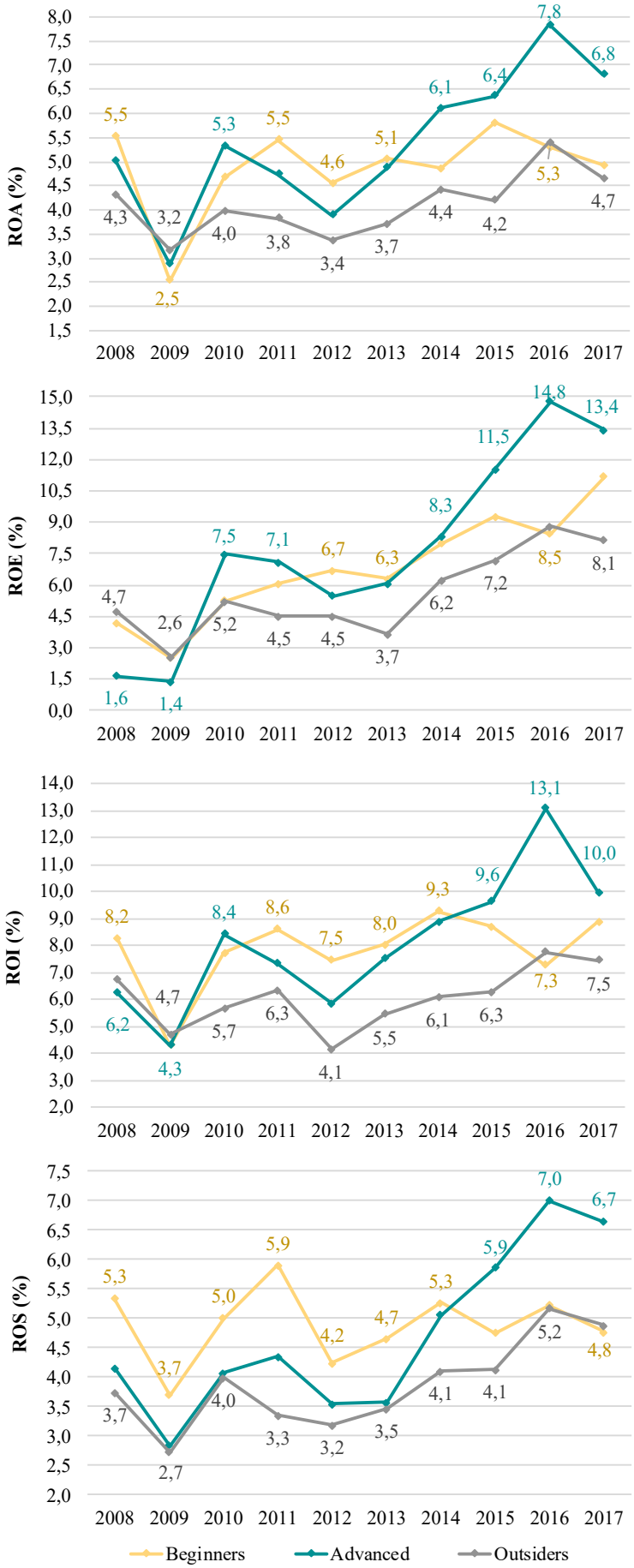
Graph 64: Leverage [n^B=142; n^A=38; n^O=198].



	Leanness maturity	
	Low	*High*
Beginners	2,83	2,47
Advanced	3,02	2,64
Outsiders	2,65	

As already stated, the profitability is measured through indexes as ROA, ROE, ROI and ROS. From *Graph 65* it is possible to note that until 2014 Beginners and Advanced companies performed – to some extent – similarly. For the two next years Advanced companies experienced a significant growth compared to Beginners even if after 2016 a decline has been recorded. When also the maturity is considered, it is possible to note that on average the Outsiders have lower ratios compared to Lean firms, but in the analysis of each subset of Lean companies the results are not consistent among them: sometimes the subset which performs better is Advanced companies with high maturity – as in the case of ROA and ROI – while some other times is the Advanced companies with low maturity – as in the case of ROE and ROS. Consequently, one can conclude that what makes the difference is being Beginner or Advanced companies while the distinction between low and high maturity does not matter in speaking about Lean and its performance.

Graph 65: ROA, ROE, ROI, ROS [n^B=142; n^A=38; n^O=198].



	Leanness maturity	
	Low	***High***
Beginners	5,0%	5,8%
Advanced	6,5%	7,3%
Outsiders	4,7%	

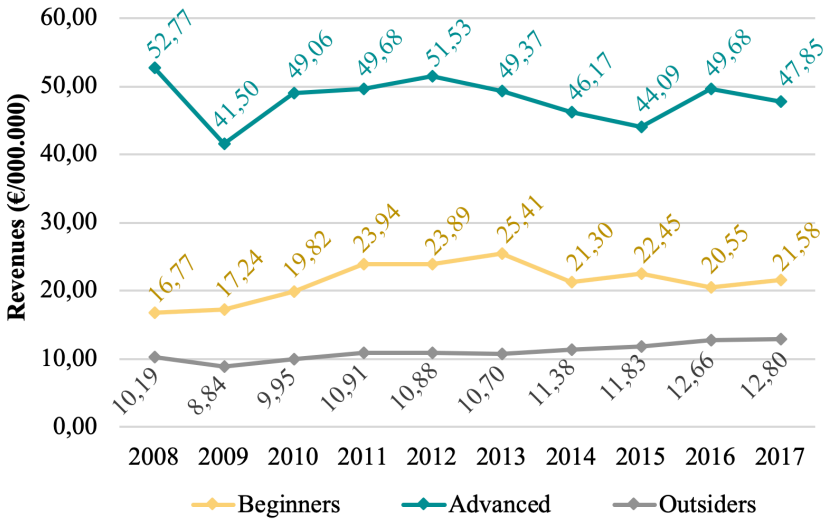
	Leanness maturity	
	Low	***High***
Beginners	9,5%	9,9%
Advanced	14,9%	12,8%
Outsiders	8,0%	

	Leanness maturity	
	Low	***High***
Beginners	7,6%	9,2%
Advanced	8,7%	11,4%
Outsiders	7,1%	

	Leanness maturity	
	Low	***High***
Beginners	4,5%	5,5%
Advanced	6,9%	6,6%
Outsiders	4,7%	

Finally, revenues are considered. *Graph 66* shows that Advanced companies are significantly larger compared to Beginners in terms of revenues. However, the right table is more valuable: Outsiders have mean revenues over the last three years lower compared to Beginners and even lower compared to Advanced companies. Both Beginners and Advanced with high maturity have greater revenues compared to their relative low maturity firms. Specifically, the revenues of Advanced firms with high maturity are twice the revenues of low maturity firms.

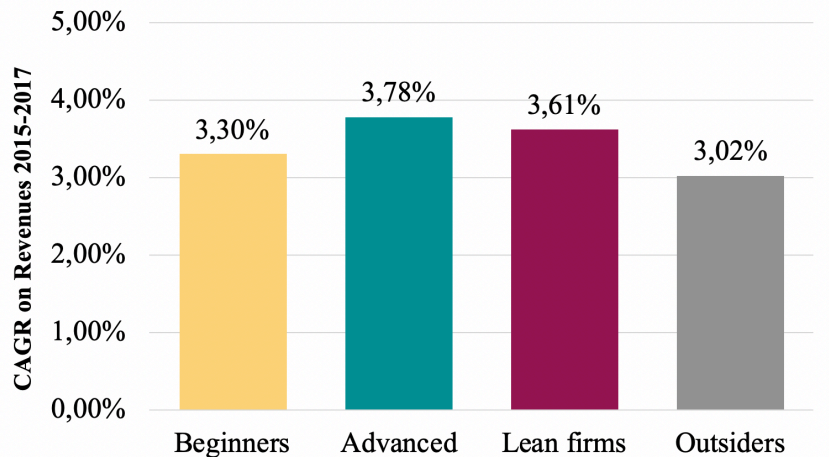
Graph 66: Revenues in €/000.000 [n^B=142; n^A=38; n^O=198].



	Leanness maturity	
	Low	*High*
Beginners	18,75	27,53
Advanced	31,32	60,94
Outsiders	12,43	

The Lean philosophy is broadly known as a growth strategy aimed to value creation (Womack et al., 1990). However, *Graph 67* does not sustain this view: one expects to find a great difference between Lean firms and Outsiders when the growth of revenues is considered because the primarily aim of Lean should be increasing revenues rather than reducing costs. Nevertheless, Graph 67 shows naturally that Advanced (3,78%) and Beginners (3,30%) grow more than Outsiders (3,02%) but the difference is not so large.

Graph 67: CAGR on revenues 2015-2017 [n^B=142; n^A=38; n^O=198].



	Leanness maturity	
	Low	*High*
Beginners	4,36%	2,88%
Advanced	3,90%	3,78%
Outsiders	3,02%	

The right tables represented from Graph 62 to Graph 67 are an attempt to summarize and make more intuitive the differences between low and high leanness maturity. However, this paper also offers the possibility to extensively see such trends over time: see *Appendix C*.

The summary of the results gained until now is provided in *Table 3*, in which the colored cells are the ones which show the best value for each index among the five groups of companies. Particularly, the Table allows to better capture how the maturity impacts on Beginners and Advanced: the result is that Advanced companies always have – except for leverage and CAGR on revenues – better values than Beginners but the best performances are sometimes related to low maturity firms and other times related to high maturity firms. Thus, from this introductive analysis – which will be faced in a more reliable and detailed way in the next chapter – it is possible to firstly hypothesized that the leanness maturity is not an element which matters.

Table 3: Summary of the financial results for category of firms.

	Beginners		**Advanced companies**		**Outsiders**
	Low maturity	**High maturity**	**Low maturity**	**High maturity**	
Ebitda-to-sales	8,30%	9,90%	10,80%	9,90%	8,70%
Value-added per capita*	67,92	70,47	89,57	78,50	69,70
Leverage	2,83	2,47	3,02	2,64	2,65
Revenues**	18,75	27,53	31,32	60,94	12,43
CAGR on revenues	4,36%	2,88%	3,90%	3,78%	3,02%
ROA	5,00%	5,80%	6,50%	7,30%	4,70%
ROE	9,50%	9,90%	14,90%	12,80%	8,00%
ROI	7,60%	9,20%	8,70%	11,40%	7,10%
ROS	4,50%	5,50%	6,90%	6,60%	4,70%

* and ** indicate that values are expressed in €/000 and €/000.000, respectively.

The analysis conducted in this chapter has started with some elaborations made from the information collected through the survey and has ended with an economic and financial deepening. All the efforts made were an attempt to identify and clarify some linkages among different subsets of companies, thus Lean firms, low and high leanness intensity firms, low and high leanness maturity firms and Outsiders. These elaborations are the milestone to perform a quantitative analysis in the next chapter, which focuses on five different groups of companies: Beginner-low maturity firms, Beginner-high maturity firms, Advanced-low maturity firms, Advanced-high maturity-firms and Outsiders.

CHAPTER 4: THE ASSESSMENT ON LEAN COMPANIES

4.1. The purpose of the research

Managers are willing to concentrate their efforts towards Lean implementation only if they expect an enhancement of the business performance. This is the reason why the first analysis performed in this paper concerns an empirical investigation about the general impact of being a Lean company on the economic and financial performance (H1). Only after such clarification it is possible to go more in-depth carrying out a more detailed Lean assessment.

Lean is spreading more and more and, even if 51% of Italian manufacturing companies do not apply it, it is a well-known concept at least at the theoretical level. Consequently, many academics and advocates are interested in performing some studies to extend the knowledge of its beneficial effects, thus inspiring the idea of this paper. Some academics claim that the Lean system can accrue benefits over time resulting in better performance, however there is a very limited empirical evidence which specifically investigates how the intensity and the length of Lean affect the financial performance. Consequently, the present paper seeks to bridge this gap in the operations management literature, testing whether leanness intensity and leanness maturity can affect significantly the business measures: they correspond to H2 and H3, respectively. In order to explore these themes in a comprehensive manner, firstly, the analysis focuses on the single events considered separately and then leanness maturity and leanness intensity are considered simultaneously in order to test H4.

Thus, Chapter 4 is dedicated to the Lean assessment. The focus is firstly on the presentation of the variables employed in the regression model, giving also evidence of their descriptive statistics. Secondly, the core of the analysis is presented, discussing on the methodology adopted and the models tested, and describing the results reached.

4.2. Presentation of the variables employed in the regression model

To build the model conducive to an explanation of the different facets of Lean related to the economic and financial performance, the information of the database gathered has been used to

define the dependent and control variables, while for the independent ones some elaborations have been made.

4.2.1. The dependent variables

Three variants of the measure of the economic and financial performance have been used as dependent variables for hypothesis testing: return on equity, return on assets and EBITDA-to-sales. These are all appropriate measures because ROE, along with ROA, is one of the all-time preferred and maybe the most widely used overall measure of corporate financial performance (Rappaport, 1986, p.31). Additionally, EBITDA-to-sales is a measure of the company's ability to improve the profitability and to reduce costs, consistent with the Lean goal of customer value creation.

Specifically, the dependent variables are the mean of the years 2015, 2016 and 2017 for each company. However, some companies within the sample do not have performance data over the three-year period because they implemented Lean in 2015 or later. Although a possible way to overcome this issue consists in removing from the database such companies, this solution would lead to distort results since it would exclude a consistent number of companies which are part of a specific group tested by the empirical analysis. The decision adopted found support in the past literature which gives evidence that the beneficial effects of Lean may be experienced by companies over a short period of time (Kim and Nakhai, 2008; Narasimhan et al., 1993). Consequently, some exceptions to the general rule need to be considered with the final goal to make the database as appropriate as possible for the purpose of the analysis. These exceptions concerns:

- 1 company became Lean in 2019 and 9 companies became Lean in 2018: they have been deleted from the database because in the period 2015-2017 they were not yet Lean companies;
- 19 companies became Lean in 2017: they have been deleted from the database because it is not possible to experience the changes in the financial performance in the same year of Lean adoption;
- 17 companies became Lean in 2016: for them, the dependent variable is the mean of the years 2016 and 2017; this choice is consistent with Kim and Nakhai (2008) according to whom firms implementing Lean programs gain performance improvements from the year after the implementation.

In the cross-sectional model, to reduce the variability within the sample it could be possible to use the logarithmic formulation, however in this case it has not been employed due to the fact that the logarithm of a negative number is undefined. To face this issue and to take into account the sector in which companies operate, it has been decided to consider the normalized value of the mean 2015-2017 of each index. The normalization has been performed considering the median value of each sector. To compute this variable, the AIDA database has been used again. In particular, the sector of each company has been identified considering the two-digit Ateco 2007 code and for each of the resulting sectors the information about each dependent variable for years 2015, 2016 and 2017 has been downloaded. However, a clarification needs to be made: in selecting the companies from the AIDA database, only the information about companies whose legal status was "active" at November 8th, 2019 has been downloaded. After that, the median value over the years selected was computed for each sector. The next step required to perform the mean of the three years, thus obtaining the sectorial mean. Finally, the original mean value of each financial index for each firm has been divided by the sectorial mean, depending on the sector of activity.

4.2.2. The independent variables: Lean-specific variables

The analysis has been performed in three different steps before reaching the final result. For this purpose, some Lean-specific variables have been considered as independent variables.

Firstly, the whole sample has been divided in two groups, using a dichotomous variable called "*Lean*" which assumes value "1" if the company adopts at least one Lean practice, or "0" otherwise. The variable "Lean" has been used to test the *Model 1*.

Secondly, another classification of the sample has been provided considering the variable "*Intensity*" which assumes value "0" for Outsider companies, value "1" for Beginner companies and value "2" for Advanced companies[16]. The variable "Intensity" has been used to test the *Model 2*.

Thirdly, the companies of the sample have been divided also according to their "*Maturity*", a variable which assumes value "0" for Outsider companies, value "1" for low leanness maturity companies and value "2" for high leanness maturity companies[17]. The variable "Maturity" has been used to test the *Model 3*.

[16] The rule followed to classify the sample according to the *intensity* is the one adopted in Chapter 3: see *Appendix B*.
[17] The rule followed to classify the sample according to the *maturity* is the one adopted in Chapter 3: "*low leanness maturity*" means that a company has applied at least one Lean technique for a period equal or lower than 6 years while "*high leanness maturity*" means that a company has applied at least one Lean technique for at least 7 years.

Finally, what becomes interesting at this point of the discussion is analyzing the extent to which the simultaneous consideration of leanness intensity and leanness maturity affects the economic and financial performance. This kind of analysis has been performed introducing the variable "*Level*" which assumes value "0" for Outsider companies, value "1" for Beginner companies characterized by low leanness maturity, value "2" for Beginner companies characterized by high leanness maturity, value "3" for Advanced companies characterized by low leanness maturity and value "4" for Advanced companies characterized by high leanness maturity. The variable "Level" has been used to test the *Model 4*.

4.2.3. The control variables

In addition to the Lean-specific variables just described, the regression models include six variables to control for elements that could potentially influence the economic and financial performance. Indeed, the lack of consideration of factors that could influence the dependent variable determines the increase in the variance of the error with respect to the one of the dependent variable, making difficult to accurately estimate the regression coefficients.

The set of control variables considered are:

- *Size*, which refers to the size of the company expressed in terms of the number of employees in 2017; this is a continuous variable.
- *Export*, which considers whether the company exports its products abroad or not; this is a dummy variable which assumes value "1" if the company is an exporter, and "0" otherwise.
- *Family business*, which considers whether the company is a family business or not; this is a dummy variable which assumes value "1" if the company is a family business, and "0" otherwise.
- *Seniority*, which refers to the years of seniority of each company, calculated as the difference between 2019 and the year of foundation; this is a continuous variable.
- *Foreign plant*, which considers whether the company owns plants abroad; this is a dummy variable which assumes value "1" if the company has at least one plant abroad, and "0" otherwise.
- *Main market*, which refers to the main market in which the company operates; this is a dummy variable which assumes value "1" if the main market is the Italian one, and "0" otherwise.

Additionally, for continuous variables – thus, the variables size and seniority – it has been considered their logarithmic value because the natural logarithm transformation allows to reduce the mean absolute deviation and to obtain a variable with a Gaussian distribution.

All the dependent, independent and control variables just explained and employed in the analysis have been summarized in *Table 4*.

Table 4: Summary of the variables employed in the analysis.

Variable	Role	Type	Description	Data source
ROE	Dependent	Continuous	Net income divided by equity	AIDA
ROA	Dependent	Continuous	EBIT divided by total assets	AIDA
Ebitda/sales	Dependent	Continuous	EBITDA divided by sales	AIDA
Lean	Independent (Model 1)	Dummy	0 = Outsider 1 = Lean	Survey
Intensity	Independent (Model 2)	Dummy	0 = Outsider 1 = Beginner 2 = Advanced	Survey
Maturity	Independent (Model 3)	Dummy	0 = Outsider 1 = Low maturity 2 = High maturity	Survey
Level	Independent (Model 4)	Dummy	0 = Outsider 1 = Beginner – Low maturity 2 = Beginner – High maturity 3 = Advanced – Low maturity 4 = Advanced – High maturity	Survey
Size	Control	Continuous	Logarithm of the number of employees in year 2017	AIDA
Export	Control	Dummy	1 = Export company 0 = Otherwise	Survey
Family business	Control	Dummy	1 = Family business 0 = Otherwise	Survey
Seniority	Control	Continuous	Logarithm of the difference between 2019 and the year of company foundation	AIDA
Foreign plant	Control	Dummy	1 = Company with at least one foreign plant 0 = Otherwise	Survey
Main market	Control	Dummy	1 = Company whose main market is in Italy 0 = Otherwise	Survey

The last step which allows to have a detailed description of the variables consists in providing their descriptive statistics, making a distinction between continuous variables – *Table 5* – and categorical ones – *Table 6*.

Table 5: Descriptive statistics of the continuous variables.

Variable	Observations	Min	Max	Mean	Standard deviation
Normalized ROE	400	-14,627	12,116	1,380	2,419
Normalized ROA	400	-6,029	14,402	1,717	2,000
Normalized EBITDA/sales	400	-6,425	10,528	1,296	1,107
Size	398	4	1621	125	207,688
Seniority	399	3	90	32	15,661

Table 6*:* Descriptive statistics of the categorical variables.

Variable	Description	*Valid* observations	*NA* observations	*Total* observations
Lean	0 = Outsider 1 = Lean	229 171	0	400
Intensity	0 = Outsider 1 = Beginner 2 = Advanced	229 130 41	0	400
Maturity	0 = Outsider 1 = Low maturity 2 = High maturity	229 74 97	0	400
Level	0 = Outsider 1 = Beginner - low maturity 2 = Beginner - high maturity 3 = Advanced - low maturity 4 = Advanced - high maturity	229 61 69 13 28	0	400
Export	1 = Export company 0 = Otherwise	343 27	30	400
Family business	1 = Family business 0 = Otherwise	282 113	5	400
Foreign plant	1 = Company with at least one foreign plant 0 = Otherwise	93 297	10	400
Main market	1 = Company whose main market is in Italy 0 = Otherwise	226 135	39	400

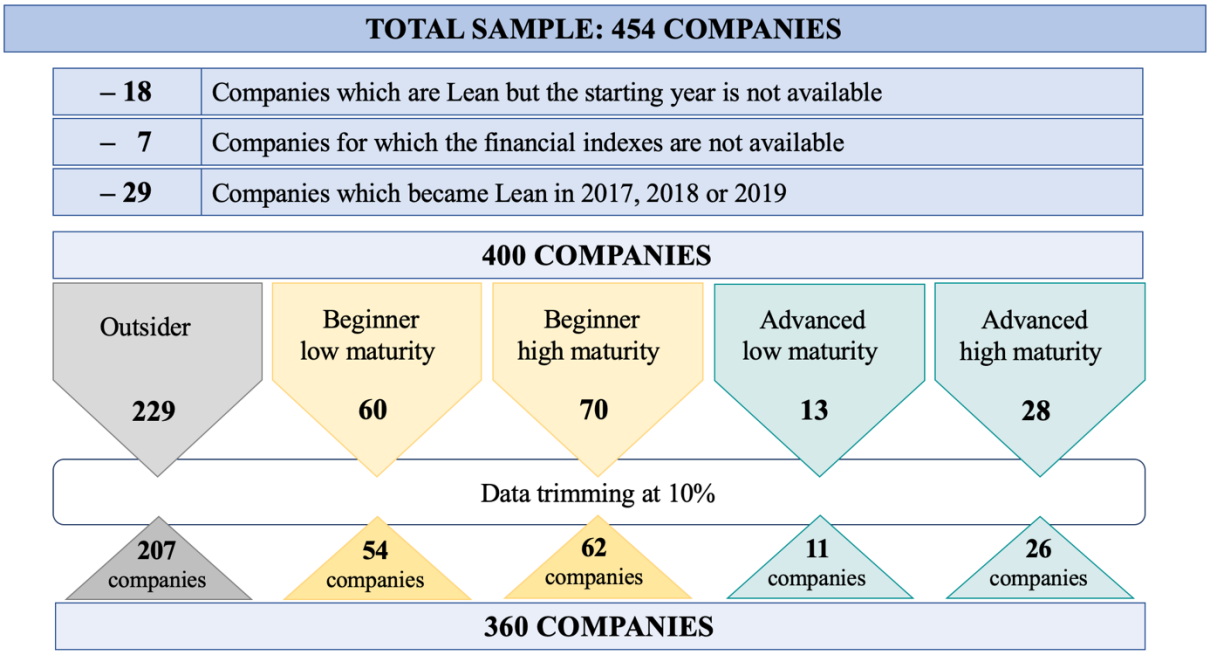
4.3. The research methodology

This paragraph aims to clarify the methodology enforced for conducting the whole study. This is a quantitative, cross-sectional research which exploits the information collected from a survey to Italian manufacturing firms in order to test – as already expressed – whether the leanness intensity and the maturity have an impact on the financial success.

In order to make the analysis as reliable as possible, some considerations have been made about the role of the outliers. In particular, 10% of the extreme data – considering time by time the three different financial indicators – have been trimmed for each category of companies identified in Model 4: Outsider, Beginner - low maturity, Beginner - high maturity, Advanced

- low maturity and Advanced - high maturity companies. The resulting database was the input to perform all the regression models. In order to be as clear as possible, *Figure 2* summarizes all the operations made to reach the final database.

Figure 2: Database cleaning preliminary for the empirical analysis.



After the presentation of the database and in light of the different types of independent variables above described, it should be clear what are the models that this paper is intended to test. The main method used is the multiple linear regression and the related parameters have been estimated through an Ordinary Least Square (OLS) regression. The rationale behind this method is the minimization of the sum of the squares in the differences between the observed and predicted values of the dependent variable configured as a straight line. The multiple linear regression is based on specific assumptions:

1. linear relationship;
2. normality of the residuals, whose mean value is equal to 0: this is tested through the Quantile-Quantile plot;
3. homoscedasticity, thus the constant variability of the residuals: this is tested through the comparison between fitted values and residuals.

These assumptions have been checked and it has been found confirmation on their validity. Additionally, another important assumption is the absence of multicollinearity, which is tested through the correlation matrix and the Variance Inflation Factor.

The multiple linear regression models tested are structured as:

$$Y = \beta_0 + \beta_1\, LEAN\ SPECIFIC\ VARIABLE\ + \beta_2\, Control\ variables,$$

where Y is the dependent variable, β_0 is the mean value of Y when the independent and control variables equal 0, β_1 is the variation of Y in correspondence of a unitary variation of the independent variable and β_2 is the variation of Y in correspondence of a unitary variation of the control variables, maintaining constant all the other variables.

In light of this clarification, the next step consists in presenting the linear regression models.

4.3.1. The regression models tested

The first model – Model 1 – refers to a broad and generic analysis performed to give an overview over the link between Lean and financial performance, thus comparing Lean and Outsider firms. Consequently, the first regression is as follows:

$$Y = \beta_0 + \beta_1\, LEAN\ + \beta_2\, Size + \beta_3\, Export + \beta_4\, Family\ business + \beta_5\, Seniority + \beta_6\, Foreign\ plant + \beta_7\, Main\ market + \varepsilon$$

The need to test this simple model relies on the previous, unclear findings which highlight the ambiguity of the empirical results about the improvements in the financial performance by Lean companies. The results of this regression are shown in *Table 7*. The Table highlights "Model 1 (A)" which includes only the independent variable and "Model 1 (B)" which adds the control variables. Model 1 (A) has been presented only for making the analysis as comprehensive as possible but what is really meaningful to consider is Model 1 (B). All three variants of the Model 1 (B) confirm that being a Lean company significantly impacts on the economic and financial performance.

Table 7: Regression model according to the independent variable "Lean".

	Model 1 (A)			**Model 1 (B)**		
	ROE	***ROA***	***Ebitda/sales***	***ROE***	***ROA***	***Ebitda/sales***
Lean companies	0,167 (0,152)	0,261* (0,145)	0,255*** (0,089)	0,344* (0,188)	0,297* (0,179)	0,161* (0,094)
Size				-0,107 (0,094)	0,037 (0,090)	0,061 (0,047)
Export				0,252 (0,342)	0,275 (0,321)	0,219 (0,167)
Family business				0,125 (0,192)	0,228 (0,183)	0,114 (0,095)
Seniority				-0,377*** (0,143)	-0,221* (0,134)	0,009 (0,069)
Foreign plant				-0,318 (0,222)	-0,287 (0,207)	-0,175 (0,109)
Main market				0,136 (0,178)	0,046 (0,171)	-0,055 (0,089)
Intercept	1,337*** (0,099)	1,573*** (0,094)	1,244*** (0,058)	2,645*** (0,624)	1,798*** (0,570)	0,773*** (0,297)
Adjusted R^2	0,0006	0,0062	0,0199	0,0224	0,0054	0,0184
Observations	360	360	360	307	303	304

Note: Standard errors in parentheses, *$p < 0,1$, **$p < 0,05$, ***$p < 0,01$.

In addition to the confirmation of the positive association between Lean and business performance, this paper adds some elements which could affect the relationship between Lean and performance. In particular, moving from the evidence that Lean firms perform better than Outsiders, it is reasonable to think that the extensive implementation of it could affect even more the performance. Consequently, Model 2 is depicted as follows:

$$Y = \beta_0 + \beta_1 INTENSITY + \beta_2\, Size + \beta_3\, Export + \beta_4\, Family\ business + \beta_5\, Seniority + \beta_6\, Foreign\ plant + \beta_7\, Main\ market + \varepsilon$$

The outcome of Model 2 is represented in *Table 8*. This model makes a distinction of Lean companies according to the number of techniques adopted, identifying Beginner and Advanced companies. Looking at the estimates of the parameters, all three financial indicators give evidence of a positive and statistically significant relationship with the companies which extensively adopt Lean practices. The significance levels are 5% in case of EBITDA-to-sales and even 1% in case of ROE and ROA.

Table 8: Regression model according to the independent variable "Intensity".

	Model 2 (A)			Model 2 (B)		
	ROE	***ROA***	***Ebitda/sales***	***ROE***	***ROA***	***Ebitda/sales***
Beginner	-0,026	0,159	0,132	0,164	0,171	0,034
	(0,164)	(0,157)	(0,084)	(0,192)	(0,185)	(0,089)
Advanced	0,771***	0,582**	0,277**	1,209***	0,893***	0,281**
	(0,252)	(0,242)	(0,129)	(0,313)	0,301	(0,142)
Size				-0,162*	0,003	0,076*
				(0,094)	(0,090)	(0,044)
Export				0,329	0,327	0,231
				(0,337)	(0,319)	(0,153)
Family business				0,142	0,232	0,093
				(0,189)	(0,181)	(0,087)
Seniority				-0,393***	-0,234*	0,007
				(0,140)	(0,133)	(0,063)
Foreign plant				-0,394*	-0,323	-0,171*
				(0,219)	(0,206)	(0,099)
Main market				0,183	0,076	0,016
				(0,175)	(0,170)	(0,082)
Intercept	1,337***	1,572***	1,244***	2,802***	1,904***	0,677**
	(0,098)	(0,094)	(0,050)	(0,615)	(0,567)	(0,271)
Adjusted R^2	0,0223	0,0110	0,0107	0,0562	0,0220	0,0233
Observations	360	360	360	307	303	304

Note: Standard errors in parentheses, *$p < 0,1$, **$p < 0,05$, ***$p < 0,01$.

The fact that Advanced perform better than Beginner companies is a further confirmation of what already hypothesized by many Lean advocates who agree on the unsatisfactory results for the lack of a comprehensive Lean system (Gilbert, 1990; Milgrom and Roberts, 1995; Fullerton et al., 2003). If the literature gives more certainties on the role of the leanness intensity, it is not the same for the leanness maturity, which has been examined through the model:

$$Y = \beta_0 + \beta_1\, MATURITY + \beta_2\, Size + \beta_3\, Export + \beta_4\, Family\ business + \beta_5\, Seniority + \beta_6\, Foreign\ plant + \beta_7\, Main\ market + \varepsilon$$

The outcome of this model is represented in *Table 9*. Focusing on Model 3 (B), it is possible to note that the leanness maturity is not an element which matters except in the case of ROE for which the low leanness maturity is significant at 5%. These results extend the doubts about the role of maturity in the Lean context.

Table 9: Regression model according to the independent variable "Maturity".

	Model 3 (A)			Model 3 (B)		
	ROE	***ROA***	***Ebitda/sales***	***ROE***	***ROA***	***Ebitda/sales***
Low maturity	0,329 (0,203)	0,319* (0,193)	0,090 (0,102)	0,498** (0,233)	0,289 (0,219)	0,020 (0,106)
High maturity	0,048 (0,181)	0,218 (0,173)	0,224** (0,092)	0,203 (0,227)	0,304 (0,221)	0,133 (0,103)
Size				-0,087 (0,096)	0,035 (0,093)	0,080* (0,044)
Export				0,251 (0,342)	0,275 (0,322)	0,213 (0,154)
Family business				0,129 (0,192)	0,229 (0,183)	0,090 (0,087)
Seniority				-0,356** (0,144)	-0,222 (0,135)	0,004 (0,063)
Foreign plant				-0,338 (0,222)	-0,286 (0,208)	-0,153 (0,100)
Main market				0,141 (0,178)	0,046 (0,171)	-0,002 (0,082)
Intercept	1,337*** (0,099)	1,573*** (0,095)	1,244*** (0,050)	2,490*** (0,639)	1,806*** (0,585)	0,704** (0,278)
Adjusted R^2	0,0018	0,0040	0,0110	0,0232	0,0021	0,0159
Observations	360	360	360	307	303	304

Note: Standard errors in parentheses, *$p < 0,1$, **$p < 0,05$, ***$p < 0,01$.

For this reason, Model 4 digs deeper into the issue focusing on four categories of Lean firms identified through a combination of the two previous models, thus comparing firms characterized by different levels of leanness intensity and leanness maturity. It follows that:

$$Y = \beta_0 + \beta_1 LEVEL + \beta_2\, Size + \beta_3\, Export + \beta_4\, Family\ business + \beta_5\, Seniority + \beta_6\, Foreign\ plant + \beta_7\, Main\ market + \varepsilon$$

The rationale behind this model is to deepen the role of the maturity in the context in which companies adopt different degrees of Lean. Looking at *Table 10*, the doubts emerged in the previous analysis about the maturity find confirmation. Focusing on ROE, the uncertainty between low and high maturity remains because both Advanced companies with low leanness maturity and Advanced companies with high leanness maturity are significant with a significance level of 1% and 5%, respectively. Conversely, it seems that for ROA and EBITDA-to-sales it could be better to be an Advanced company which experiences Lean for a short period of time rather than for a longer timespan.

Table 10: Regression model according to the independent variable "Level".

	Model 4 (A)			**Model 4 (B)**		
	ROE	***ROA***	***Ebitda/sales***	***ROE***	***ROA***	***Ebitda/sales***
Beginner - Low maturity	0,067 (0,214)	0,113 (0,206)	0,015 (0,110)	0,232 (0,242)	0,041 (0,229)	-0,078 (0,111)
Beginner - High maturity	-0,106 (0,203)	0,199 (0,195)	0,234** (0,104)	0,099 (0,239)	0,300 (0,234)	0,142 (0,110)
Advanced - Low maturity	1,613*** (0,434)	1,332*** (0,418)	0,461** (0,222)	1,918*** (0,461)	1,636*** (0,456)	0,540** (0,220)
Advanced - High maturity	0,415 (0,292)	0,265 (0,281)	0,200 (0,150)	0,776** (0,372)	0,511 (0,356)	0,161 (0,167)
Size				-0,136 (0,095)	0,006 (0,092)	0,071 (0,044)
Export				0,300 (0,336)	0,292 (0,318)	0,214 (0,153)
Family business				0,145 (0,188)	0,231 (0,180)	0,098 (0,086)
Seniority				-0,356** (0,141)	-0,225* (0,133)	0,009 (0,063)
Foreign plant				-0,436** (0,219)	-0,349* (0,205)	-0,173* (0,099)
Main market				0,191 (0,174)	0,072 (0,169)	0,012 (0,082)
Intercept	1,337*** (0,098)	1,573*** (0,094)	1,244*** (0,050)	2,600*** (0,627)	1,898*** (0,577)	0,706** (0,276)
Adjusted R^2	0,0333	0,0191	0,0153	0,0643	0,0332	0,0331
Observations	360	360	360	307	303	304

Note: Standard errors in parentheses, *$p < 0,1$, **$p < 0,05$, ***$p < 0,01$.

Finally, the last remark on the Table just presented concerns the adjusted R^2: for the three performance measures in models 4 (B) it ranges from 3,3% for ROA and EBITDA-to-sales to 6,4% for ROE, indicating that other significant measures affecting firm performance have not been captured in the equations.

4.3.2. The role of maturity on the Lean journey

What has emerged until now is about an ambiguous role of the leanness maturity: this is the reason why some other models will be presented in order to strengthen the results.

Consequently, in *Table 11* some OLS regressions have been performed to address the hypothesis according to which the maturity impacts the relationship between Lean and financial performance, by using ROE, ROA and EBITDA-to-sales as dependent variables. In order to perform this analysis, two more variables have been introduced:

- *Lean intensity*: it is a continuous variable which indicates the number of Lean techniques adopted by each company; in case of Outsider firms, Lean intensity equals zero.

- *Lean maturity*: it is a continuous variable which indicates the number of years of Lean experienced by each company in 2019; in case of Outsider firms, Lean maturity equals zero.

Model 5 (A) includes the variables Lean intensity and Lean maturity to test for their direct effects on the financial performance, in addition to the control variables. Model 5 (B) does not include the control variables but it adds the interaction term between Lean intensity and Lean maturity to test for the moderation effect. Model 5 (C) provides a complete analysis which shows both the interaction term and the control variables.

Model 5 (A) shows that Lean intensity is significantly related to the financial performance, supporting the results reached by Model 2. For what concerns the Lean maturity, its coefficient is not significant, a result confirmed also by Model 5 (B) and Model 5 (C). Additionally, these models show that Lean maturity does not moderates the positive effect of Lean intensity on financial performance.

Table 11: The moderation effect of the leanness maturity.

	Model 5 (A)			**Model 5 (B)**			**Model 5 (C)**		
	ROE	***ROA***	***Ebitda/ sales***	***ROE***	***ROA***	***Ebitda/ sales***	***ROE***	***ROA***	***Ebitda/ sales***
Lean intensity	0,023*** (0,008)	0,015* (0,008)	0,007* (0,004)	0,021* (0,011)	0,019* (0,010)	0,012** (0,006)	0,034*** (0,012)	0,024** (0,012)	0,011* (0,006)
Lean maturity	-0,008 (0,018)	0,008 (0,018)	0,011 (0,011)	-0,004 (0,018)	0,012 (0,018)	0,016* (0,009)	0,005 (0,021)	0,018 (0,021)	0,012 (0,010)
Lean intensity x lean maturity				-0,0009 (0,001)	-0,001 (0,001)	-0,001* (0,001)	-0,001 (0,001)	-0,001 (0,001)	-0,001 (0,001)
Size	-0,147 (0,097)	-0,0002 (0,0005)	-0,088 (0,071)				-0,142 (0,097)	0,009 (0,094)	0,076* (0,044)
Export	0,301 (0,340)	0,286 (0,316)	-0,234 (0,386)				0,277 (0,340)	0,284 (0,321)	0,203 (0,153)
Family business	0,147 (0,191)	0,221 (0,180)	0,158 (0,134)				0,147 (0,191)	0,240 (0,182)	0,092 (0,087)
Seniority	-0,372*** (0,142)	-0,010* (0,005)	0,056 (0,101)				-0,361** (0,142)	-0,218 (0,134)	0,015 (0,063)
Foreign plant	-0,347 (0,219)	-0,271 (0,208)	0,112 (0,136)				-0,376* (0,220)	-0,320 (0,207)	-0,180* (0,099)
Main market	0,176 (0,177)	0,063 (0,171)	0,047 (0,121)				0,178 (0,177)	0,070 (0,172)	0,011 (0,082)
Intercept	2,717*** (0,630)	1,526*** (0,377)	1,428** (0,556)	1,333*** (0,095)	1,576*** (0,091)	1,232*** (0,048)	2,657*** (0,632)	1,849*** (0,580)	0,662** (0,275)
Adjusted R^2	0,0359	0,0129	-0,0091	0,0044	0,0057	0,0154	0,0371	0,0101	0,0226
Observations	307	303	304	360	360	360	307	303	304

Note: Standard errors in parentheses, $*p < 0,1$, $**p < 0,05$, $***p < 0,01$.

To be sure of these results, the role of maturity has been tested adopting also another approach. In this case, to avoid being too wordy, this test has been made considering only one dependent variable, the return on equity. The procedure consists in a two-step regression, as shown in

Table 12. The first step consists in performing a regression over the ROE considering only the control variables, indeed this is what needed to calculate the residuals of the return on equity relative to control variables. Then, the second step consists in performing a regression of the residuals over the variable "Level" – without considering the intercept – in order to stress the effect of the just mentioned variable "Level".

Table 12: Two-step regression to test the role of the maturity.

	Dependent variable	
	Step 1: ROE	***Step 2: Residuals***
Outsider		-0,062 (0,162)
Beginner - Low maturity		-0,176 (0,269)
Beginner - High maturity		-0,348 (0,295)
Advanced - Low maturity		1,208** (0,601)
Advanced - High maturity		0,172 (0,491)
Size	-0,039 (0,103)	
Export	-0,024 (0,516)	
Family business	0,336 (0,276)	
Seniority	-0,167 (0,200)	
Foreign plant	-0,187 (0,308)	
Main market	0,214 (0,258)	
Intercept	1,736** (0,849)	
Adjusted R^2	-0,0054	0,0031
Observations	307	307

Note: Standard errors in parentheses, *p < 0,1, **p < 0,05, ***p < 0,01.

These regressions are the input to test whether there is a significant difference between two groups of companies, using the estimates of the parameters β and their related standard errors. To do this, it has been used the Wald test, which works by testing the null hypothesis that a set of parameters is equal to some value. Consequently, this test is based on the following system of hypotheses:

$$\begin{cases} H_0: \beta_{Beg-low\ maturity} = \beta_{Beg-high\ maturity} & if\ \hat{\delta} \in confidence\ interval \\ H_1: \beta_{Beg-low\ maturity} \neq \beta_{Beg-high\ maturity} & if\ \hat{\delta} \notin confidence\ interval \end{cases}$$

Conversely, when the Advanced companies are considered, it becomes as follows:

$$\begin{cases} H_0: \beta_{Adv-low\ maturity} = \beta_{Adv-high\ maturity} & if\ \hat{\delta} \in confidence\ interval \\ H_1: \beta_{Adv-low\ maturity} \neq \beta_{Adv-high\ maturity} & if\ \hat{\delta} \notin confidence\ interval \end{cases}$$

After that, it only remains to calculate $\hat{\delta}$ and to check whether this value is within the confidence interval $\pm$ 1,96, thus considering a confidence interval of 95%. Firstly, $\hat{\delta}$ has been calculated for Beginner companies, comparing their "Low maturity" and "High maturity" values:

$$\hat{\delta} = \frac{\beta_{Beg-low\ maturity} - \beta_{Beg-high\ maturity}}{SE(\beta_{Beg-low\ maturity}) + SE(\beta_{Beg-high\ maturity})}$$

Secondly, the same procedure has been followed for the Advanced companies:

$$\hat{\delta} = \frac{\beta_{Adv-low\ matuirty} - \beta_{Adv-high\ maturity}}{SE(\beta_{Adv-low\ maturity}) + SE(\beta_{Adv-high\ maturity})}$$

Substituting with the values found on Table 12, the formulas become:

$$\hat{\delta}_{Beginner} = \frac{-0{,}17607 - (-0{,}34803)}{0{,}26894 + 0{,}29545} = 0{,}3047$$

$$\hat{\delta}_{Advanced} = \frac{1{,}20835 - (0{,}17191)}{0{,}60136 + 0{,}49101} = 0{,}9488$$

In both cases the result is that $\hat{\delta}$ is included within the confidence interval, meaning that there is not a statistically significant difference between Beginner and between Advanced companies characterized by different levels of maturity.

To conclude, the two tests here above described reached the same conclusion. This allows to state with a considerable certainty that the maturity – differently from the intensity – is not a factor which affects the economic and financial performance of a company engaged on Lean programs.

4.3.3. Robustness analysis

To verify the robustness of the analysis some tests have been performed.

Firstly, the most important test which allows to verify the acceptability of the results has been already performed. Indeed, the results presented from Table 7 to Table 11 are not based only on one financial indicator but, conversely, they are simultaneously confirmed by three variants of the economic and financial performance measures.

Secondly, the *test RESET* allows to test the specification of the linear regression model, identifying whether non-linear combinations of the parameters help to explain the dependent variable. In particular, if non-linear combinations of the control variables are able to explain the dependent variable, the model suffers of misspecification meaning that the model may be better specified by a polynomial or other non-linear functional models. In practical terms, if the p-value is below the α level decided, the null-hypothesis that there is no significant difference among the models is rejected and consequently the model suffers from misspecification. The results of test RESET are shown in *Table 13* where it is possible to notice that for all the three dependent variables the null hypothesis cannot be rejected: all the models do not suffer from misspecification.

Table 13: The test RESET for the linear models analyzed.

Models tested	**P-value**		
	Y = ROE	***Y = ROA***	***Y = Ebitda/sales***
Y = Lean + Control variables	0,1878	0,6788	0,6531
Y = Intensity + Control variables	0,4391	0,2201	0,1054
Y = Maturity + Control variables	0,3413	0,6854	0,6192
Y = Level + Control variables	0,4341	0,1140	0,5237

Lastly, the *correlation matrix* of the continuous variables has been displayed in *Table 14*. The correlation matrix has the purpose to describe how the different variables are related to each other, and it helps to identify the presence of multicollinearity problems, which occur when one variable of the model is linearly predicted by others with a substantial degree of accuracy. In case of multicollinearity, the model involves distorted estimates of the parameters, thus leading to incorrect evaluations of the results obtained. Note that the correlation matrix includes only the continuous variables while the dichotomous ones have been excluded.

The results of the correlation matrix suggest that a correlation is in place among ROE, ROA and EBITDA-to-sales but this is an expected result looking at their similar formula and this does not represent a problem because they are employed in the model alternatively. Additionally, excluding the dependent variables, the highest correlations are in place between

Lean maturity and Lean intensity (0,5562) – such a high correlation has been confirmed also by Camuffo and Gerli (2016) – and between Lean intensity and size (0,4045). Nevertheless, even if the correlations are significant, they are not so high to seriously affect the quality of the regression model: indeed, the correlations are all below the worrying threshold of 0,5, with only one exception.

Table 14: The correlation matrix [n^L=171; n^O=229].

	1	2	3	4	5	6	7
1, Normalized ROE	1,0000						
2, Normalized ROA	0,7154***	1,0000					
3, Normalized Ebitda/sales	0,4556***	0,7354***	1,0000				
4, Size	-0,0224	0,0088	-0,0254	1,0000			
5, Seniority	-0,0612	-0,0289	0,0508	0,0131	1,0000		
6, Lean intensity	0,0104	0,0013	-0,0115	0,4045***	-0,0109	1,000	
7, Lean maturity	-0,0388	0,0034	-0,0174	0,3111***	0,1022**	0,5562***	1,0000

Note: *p < 0,1, **p < 0,05, ***p < 0,01.

For further examination of multicollinearity, it was checked the Variance Inflation Factor – VIF – for all the regression models tested. The results find 1,0526 and 1,4483 as opposite extreme values, values which are well under the cutoff score of 10[18] (Thompson et al., 2017).

[18] VIF = $\frac{1}{1-R^2}$. The cutoff value of 10 is associated to a R^2 of 0.90.

CHAPTER 5: CONCLUSIONS

5.1. Discussion of the main results

The Lean philosophy is a recent phenomenon which currently finds applicability in 49% of the Italian manufacturing companies, which approached it mainly for the need to improve the operational performance (74%) and for the willingness to change the management logic (70%). Since the last years of the past century, the consequences of Lean transformations have been widely discussed in literature, which in some cases finds out mixed results, both from a theoretical and an empirical viewpoint. Nevertheless, the Lean philosophy has become an essential organizational method for nowadays companies which spans over different functional areas with a predominant application in production (96%). Hence, precisely, this paper tried to understand what are the characteristics which allow it to be the method that guarantees more efficiency in the modern business world, focusing on two specific features which potentially affect the financial side of Lean: the leanness intensity and the leanness maturity.

Beyond many anecdotal insights related to cases of Operational Excellence and some quantitative researches with limited capacity of generalization, there is no systematic evidence of the dissemination level of good managerial practices, especially for small and medium Italian manufacturing companies and their actual impact on the economic and financial indicators. The aim of this paper is in line with all those scholars that are trying to assess whether there is a positive relationship between the Lean philosophy and the business performance, moving from the assumption that leanness assessment is essential to monitor achievements, identify new objectives and measure the extent of potential improvements (Pakdil and Leonard, 2015). Consequently, during this largely theoretical debate, four research propositions have been identified.

Considering the doubtful scenario, this paper aims to ascertain or refute the beliefs already popular in literature about the link which lies between Lean and financial performance. The starting point was a regression to test the broad effect of being a Lean company on the economic and financial performance, regardless the intensity and the maturity levels (H1). Given the

outcome reached, Italian companies can expect positive financial results from Lean transformations: this result does not explain the skepticism on the financial impact of Lean, witnessed by the only 32% of companies which approach it for a need to improve the financial performance.

Nevertheless, this is not what the paper aims to investigate which is – in contrast – the definition of ad hoc answers for the most uncertain results. In order to approach the core of the research, Beginner and Advanced companies have been tested (H2), indeed – in line with Fullerton et al. (2003) – it is more important to analyze the potential benefits of Lean in terms of performance by measuring manufacturing practices that reflect its application, rather than to examine its overall implementation. The empirical model drafted to test the truthfulness of the positive liaison between Lean and intensity perfectly supports such event hypothesized, finding that the best performing Lean companies are the ones which completely embrace the Lean philosophy, which accept and agree with its principles. Thus, Lean should be systematically implemented to develop an integrated system whereas a fragmented implementation does not make sense because it does not guarantee any performance improvement (Shah and Ward, 2003; White and Prybutok, 2001; Lucey et al., 2005; Camuffo and Gerli, 2016). Nevertheless, the companies that can be considered aligned with this though are only 10% of the sample against the 39% which are at their initial level of Lean implementation.

These are the steps needed to approach the real core of this paper, which is a focus on the maturity, starting from some considerations on the mere role of the maturity (H3) and then enlarging the scope of the analysis exploring the topic in relation with some other elements. The shortage and the uncertainty on the literature over this area of investigation are the main reasons why this study has been drafted, becoming also a way to critically discuss the most ambiguous outcomes reached by advocates. The ambiguity emerged through the literature review is mirrored also on the results of the regression model in Table 9: it seems that both low and high maturity are not statistically significant neither for ROA nor for EBITDA-to-sales, while for ROE there is a significance level of 5% for low maturity companies. These results lead to think that maturity is not an element that matters, bringing out the doubt that it could be even better to experience Lean for a short period of time. Since the literature is conflicting, the only way to make a valuable contribution was to perform more targeted analyses.

The lack of the current literature is that researchers fail to capture the interdependency among multiple facets of Lean, indeed the majority of them limit their analysis on the effect of a single aspect of Lean on the economic and financial performance. Consequently, this paper tried to broaden the focus, analyzing no more the single effect of the maturity but – in contrast –

combining it with the intensity (H4) and hoping to find significant results. This kind of analysis identifies four classes of Lean companies – Beginner-low maturity, Beginner-high maturity, Advanced-low maturity and Advanced-high maturity-firms – in addition to the Outsiders. For sure the investigation on these five subsets of companies allows to strengthen the fact that it is better to be an Advanced company rather than a Beginner one indeed, regardless the maturity, what results significant in this regression always concerns the group of companies which extensively adopt Lean practices. Unfortunately, the ambiguity on the maturity still persists: while in case of ROE both Advanced companies characterized by low maturity and Advanced companies characterized by high maturity are significant, for ROA and EBITDA-to-sales only data relative to the former group of companies are statistically significant.

Intensifying the analysis, the deepening that has been performed considers the maturity as a potential moderator on the relationship between leanness intensity and business performance, but this is the confirmation that the Lean experience does not moderate the positive and significant effect of the intensity. In light of these results it is clear that the much debated concept of time compression diseconomies does not find any applicability in Lean investments, meaning that earlier Lean adopter does not necessarily gain more profits when the process occurs with a faster speed.

To ease the interpretation, *Table 15* summarizes the results that have been initially hypothesized by Chapter 3 and, later, that have been confirmed through the analysis performed in Chapter 4.

Table 15: Summary of the main results.

Hypotheses	Lean-specific variables	Results
Hypothesis 1	Lean	Lean positively affects the economic and financial performance
Hypothesis 2	Intensity	Leanness intensity positively affects the economic and financial performance
Hypothesis 3	Maturity	Leanness maturity does not necessarily affects the economic and financial performance
Hypothesis 4	Level	Advanced companies characterized by high leanness maturity do not necessarily experience better financial performances compared to the other groups of companies.

This fine-grained analysis completes the existing literature and should help firms to think about whether their Lean position might be improved to reach better financial results. In other words, production managers or Lean managers should be aware of the contribution of Lean production on the financial performance and consequently, according to Agus and Iteng (2013), manufacturing companies should emphasize a greater degree of management support for Lean production enhancement initiatives.

5.2. Contributions of the research

This study contributes to the Lean literature in different ways.

Primarily, many researches give more attention in testing the financial differences between Lean adopters and non-adopters (Balakrishnan et al., 1996; Callen et al., 2000; Kinney and Wempe, 2002; York and Miree, 2004). In contrast, this paper wants to capture the extent to which companies rely on a low or high leanness intensity and leanness maturity levels making possible, in this way, a more comprehensive assessment of the correlation between Lean and financial performance. Although the current literature explains the individual impact of leanness intensity (Fullerton et al., 2003; Losonci and Demeter, 2013) and leanness maturity (Hendricks and Singhal, 2001; Kinney and Wempe, 2002) on financial performance, further investigation – which is provided by this paper – is required to analyze the simultaneous effect that these two aspects have on the economic and financial performance. Consequently, this study provides additional insights into the uncertain relation among these three variables.

Secondly, taking into account the investigation on the leanness intensity, the contribution of this paper is twofold: on one side, it offers a graphical overview on some relevant aspects and then, more importantly, a careful and detailed graphical description of the two subsets of companies identified through their leanness intensity; on the other side, it provides a cross-sectional comparison of companies which have or have not adopted a comprehensive Lean system. A further related strength results in this paper: previous studies which tested the intensity of Lean relied on data collected from questionnaires in which the related topic was intuitively assessed by respondents using a tier score. For instance, Soriano and Forrester (2002) made a survey in which respondents rated the commitment to each Lean practice according to a seven-point Likert scale thus including in the analysis the bias of human perception in awarding score to Lean application (Susilawati et al., 2015). Given the high degree of subjectivity of these studies, in this work a different approach has been used: the intensity of Lean has been assessed considering the number of practices adopted by each company in different organizational fields and the related categories of companies have been identified through the Pareto 80/20 law.

Thirdly, the originality of this study is not about the choice to further investigate the leanness maturity itself – even if this is for sure a support to the current ambiguous literature – but, instead, its uniqueness concerns the approach adopted to perform the investigation: differently from the authors who studied the impact of the maturity considering the change in the financial performance year-by-year (Hendricks and Singhal, 1997) or comparing the performance some years pre- and post- adoption (Balakrishnan et al., 1996; Kinney and Wempe, 2002), this paper

takes into account the leanness maturity in relation to the extent to which Lean practices are implemented within the organizational context. Indeed, to the best of the author's knowledge, no study on Lean and financial performance has yet successfully addressed the research question proposed through the Hypothesis 4.

Finally, what makes this paper worth is that the results reached through the empirical investigation – which considers three different financial indicators and different regression models – have been additionally confirmed by the graphical findings highlighted in the initial economic and financial results in Chapter 3 and then summarized in Table 3.

5.3. Limitations and future research opportunities

As any research, this study has a number of limitations which might reduce the generalizability and applicability of the research findings.

The first limitation concerns the survey submitted to the extent in which it is necessary to assume that respondents have the right knowledge to answer all questions truthfully and conscientiously. The questions might be formulated in a way which could be affected by subjectivity of the respondents, in addition to a reluctancy to spend time in order to deepen the specific meaning of the Lean terminology.

Second, a crucial element of this study is the identification of the parameter according to which the companies of the sample can be classified in low or high leanness intensity firms, and low or high leanness maturity firms. This is a choice of the author and consequently a certain degree of subjectivity affects the analysis: it is possible to assume that using different parameters the results could be different.

Third, a so meticulous analysis which clusters companies in five different groups meets the big limitation of having some clusters with only few observations. Indeed, the sample of Advanced companies characterized by low leanness maturity and especially the sample of Advanced companies characterized by high leanness maturity are confined to a limited number of observations, meaning that there is a higher probability that these companies are non-representative of their category – thus affecting the reliability of the analysis.

Even if these limitations suggest caution in interpreting the findings, they may also suggest the direction for interesting future research opportunities. These opportunities are mainly expressed in terms of further enlargement of the sample size. Additionally, a time-series regression model could be used to deepen the time-dependent structure of the financial side of Lean indeed longitudinal researches are considered to be real-time studies and are more suitable due to the

long lasting Lean implementation process. Just as an example, it would be possible to test whether Advanced companies with high leanness maturity will experience better financial performance over time than Advanced companies with low leanness maturity, or similarly taking into consideration two other subsets of Lean companies.

This study expands the opportunity for investigators to apply a similar research approach also to companies which operate in the service sector, which is considered the fastest growing one in Italy. Indeed, it could become interesting to explore if the Lean philosophy has a similar effect on the financial performance of service companies as the effect it has on the financial performance of the manufacturing ones.

To conclude, despite such research has allowed to strengthen the literature over the relation between Lean and financial performance, future researches can further contribute to explore different facets of such liaison and, more importantly, can validate or deny the relevant findings of this paper.

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APPENDIX

Appendix A: The OELM survey[19]

The OELM survey has been submitted to *all Italian manufacturing companies* with the purpose of investigating the *dissemination of "Operational Excellence and Lean Management" practices* and their impact on the *economic-financial performance* of the companies. The survey is addressed at both companies that adopt Lean practices and those that do not.

Section 1: Overview of the company and its characteristics

1. *Respondent role in the company*

2. *Company name*

3. *Turnover of the year 2018*

4. *Percentage of turnover of the year 2018 realized abroad*

5. *Number of employees*

6. *Percentage of blue collars on the total number of employees*

7. *Is the company a family business?* (With family business we mean a company whose owners are directly involved in its management)

☐ Yes

☐ No

[19] The survey has been translated in English but originally it was sent in Italian to Italian manufacturing companies.

8. *In which region is the operational headquarter located?*

9. *In which province is the operational headquarter located?*

10. *Does the firm own manufacturing facilities abroad? If yes, where are they located?*

- ☐ No plant abroad
- ☐ Europe (excluding Russia)
- ☐ Russia
- ☐ Asia (excluding China)
- ☐ China
- ☐ Africa
- ☐ North America
- ☐ Latin America
- ☐ Oceania

11. *Indicate the percentage of turnover 2018 for each type of customer:*

Final costumers	
Distributors	
Industrial companies	
Others	

12. *Indicate which Country represents the main market for the company and the percentage of revenues 2018 realized in that country*

Main Market	
Revenues on Total (%)	

13. *How many blue collars, in percentage on the total of them, are able to work in more than one workstation* (job rotation)*?*

14. *Indicate which percentage of the Total Revenues falls within the following categories:*

Design to order	
Manufacture to order	
Assembly to order	
Make to stock	

15. *What is your productive layout?*

- ☐ Fixed-position layout
- ☐ Functional layout
- ☐ Cell layout
- ☐ Line layout

16. *Does your company use one or more of the following technologies (Industry 4.0)?*

- ☐ Robotics in manufacturing
- ☐ Additive manufacturing
- ☐ Laser cutting
- ☐ Data processing systems
- ☐ Scanner 3D
- ☐ Augmented reality
- ☐ Internet of Things / Smart products
- ☐ None

17. *If the company adopts the technologies above mentioned, indicate in which year they have been introduced*:

Robotics in manufacturing	
Additive manufacturing	
Laser cutting	
Data processing systems	
Scanner 3D	
Augmented reality	
Internet of Things / Smart products	
None	

Section 2: Techniques and solutions adopted

18. *Do you apply any lean technique?*

- ☐ Yes
- ☐ No

19. *Why don't you adopt Lean Management practices?*

- ☐ Lack of economic resources
- ☐ Lack/limited internal skills
- ☐ Lack of a proper internal technological infrastructure
- ☐ Poor knowledge about Lean
- ☐ Uncertainty of investment returns
- ☐ It is not of interest in our business
- ☐ Lean practices still under assessment
- ☐ Other (please specify)

20. *In which year did you start implementing Lean techniques?*

21. *Why did you start implementing Lean techniques?*

- ☐ Specific requests of customers
- ☐ Request from banks/lenders
- ☐ Need of improving the economic/financial performance (e.g. crisis, need of organizational restructuring)
- ☐ Need of improving the operational performance (e.g. services, efficiency, quality…)
- ☐ Willingness of managers to modify the management logic
- ☐ Imitation of customers/suppliers/competitors
- ☐ Other (please specify)

22. *Are there people within your company who are exclusively involved in the implementation of Lean techniques?*

- ☐ Yes
- ☐ No

23. *Do you rely also on external consultants for the implementation of Lean techniques?*

☐ Yes

☐ No

24. *Are Lean techniques implemented also abroad?*

☐ Yes

☐ No

☐ There are not any plants abroad

25. *Indicate which of the following tools the company currently adopt and in which areas*:

	Production	Warehouse	Internal logistic	Quality control	Purchasing	Sales	Technical office	Administration & Control	IT
Value Stream Mapping									
5S									
A3									
Pull/Kanban									
Flow layout									
Visual management									
Standardized work									
Kaizen									
Poka Yoke									
Total Productive Maintenance									
Suggestion system									
Simultaneous engineering									
Heijunka									
Six Sigma									
Single Minute Exchange Die									
Andon									

26. *What people actively participate in the Lean transformation?*

- ☐ CEO
- ☐ Executives
- ☐ Managers
- ☐ Operators
- ☐ Other (please specify)

27. *Who is the main supporter of Lean practices?*

- ☐ Owners/CEO
- ☐ Executives
- ☐ Managers
- ☐ Other (please specify)

28. *In which kind of training did you invest?*

- ☐ Master / Training courses for employees, executives and/or managers
- ☐ Workshop / Training courses for workers
- ☐ Other (please specify)

29. *What is the percentage of employees involved in Lean projects?*

30. *Do you use any suggestion system within your company?*

- ☐ Yes
- ☐ No

31. *Are workers directly involved in the improvement process?*

- ☐ Yes
- ☐ No

32. *In percentage, how many suggestions received from workers are actually implemented?*

33. How much has been invested in Lean projects during the last 3 years?

34. Which of the following possibilities better explain your approach to detect any anomalies and issues?

- ☐ The quality control office is responsible to detect defective products and anomalies in the production process
- ☐ Workers detect possible product or process anomalies, but they are not allowed to stop the production process
- ☐ Workers detect possible product or process anomalies and stop the production process in order to implement the needed corrective actions
- ☐ Other (please specify)

35. Which of the following possibilities better explain your approach to allocate the responsibilities and supervision tasks?

- ☐ Responsibility is centralized: supervision and control activities are performed by the department head
- ☐ Responsibility is decentralized: supervision and control activities are performed directly within the teamwork by one or more members of it
- ☐ Responsibility is decentralized: supervision and control activities are performed directly within the teamwork and they are allocated to all members in rotation
- ☐ Other (please specify).

Appendix B: Application of the Pareto 80/20 law

Data are presented in descending order according to the number of Lean techniques, in order to simplify the application of the Pareto 80/20 law.

	Number of Lean techniques implemented	Leanness intensity compared to the company with 57 techiques[20]	Number of Lean firms
ADVANCED	86	151%	1
	85	149%	1
	57	**100%**	**1**
	56	98%	1
	55	96%	1
	53	93%	1
	52	91%	1
	50	88%	1
	49	86%	1
	47	82%	1
	45	79%	2
	44	77%	1
	42	74%	1
	41	72%	1
	40	70%	1
	39	68%	4
	38	67%	2
	37	65%	2
	36	63%	2
	35	61%	1
	34	60%	3
	33	58%	3
	32	56%	1
	31	54%	2
	30	53%	1
	29	51%	1
	28	49%	1
	27	47%	1
	26	46%	1
	25	44%	4
BEGINNERS	24	42%	4
	23	40%	3
	22	39%	7
	21	37%	4
	20	35%	5
	19	33%	6
	18	32%	4
	17	30%	4
	15	26%	7
	14	25%	5
	13	23%	6
	12	21%	6
	11	19%	12
	10	18%	8
	9	16%	15
	8	14%	11
	7	12%	7
	6	11%	4
	5	9%	12
	4	7%	15
	3	5%	10
	2	4%	11
	1	2%	10
	TOTAL LEAN FIRMS		**221**

Firms		
	Number	45
	%	20%

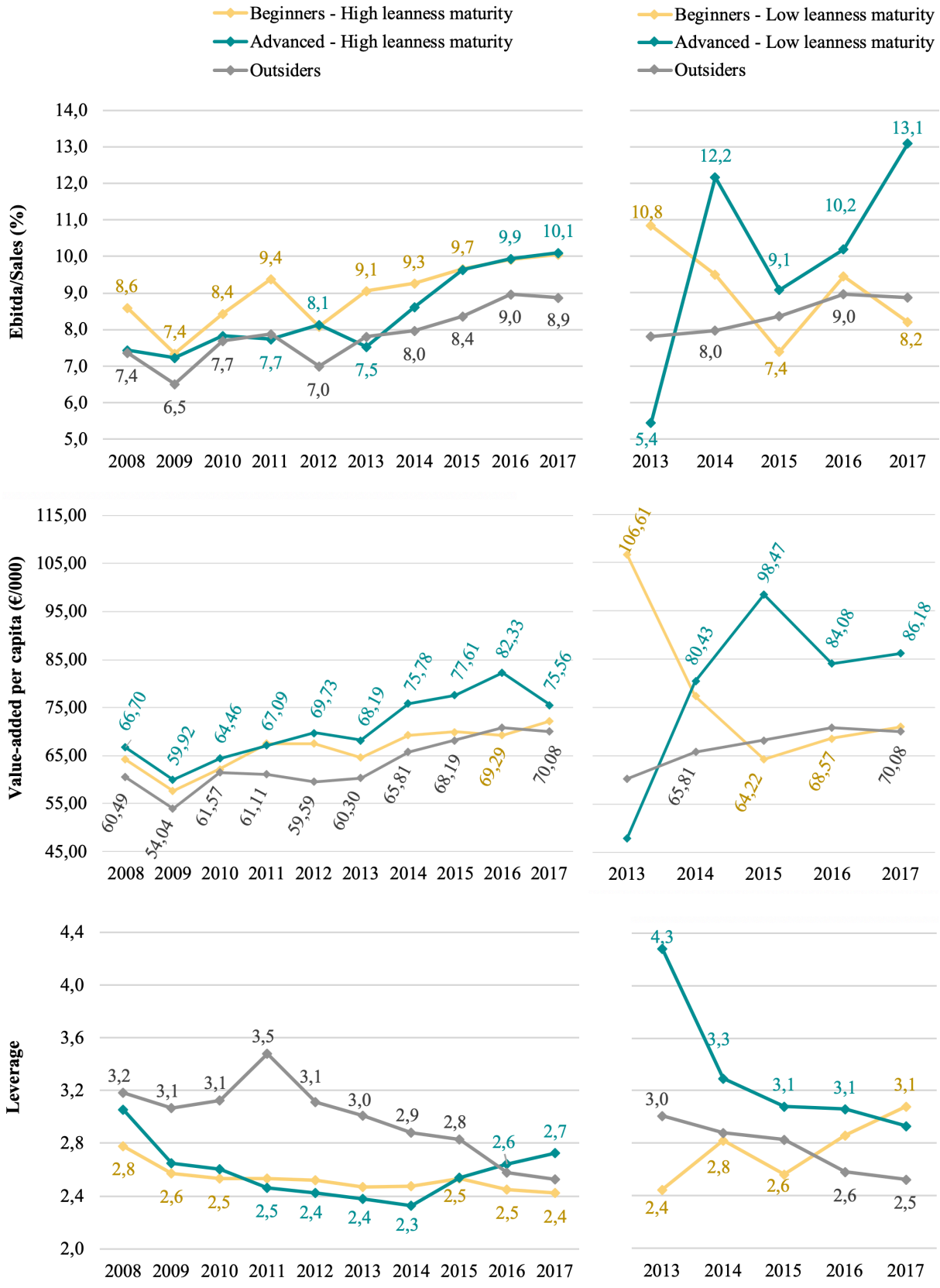
Firms		
	Number	61
	%	28%

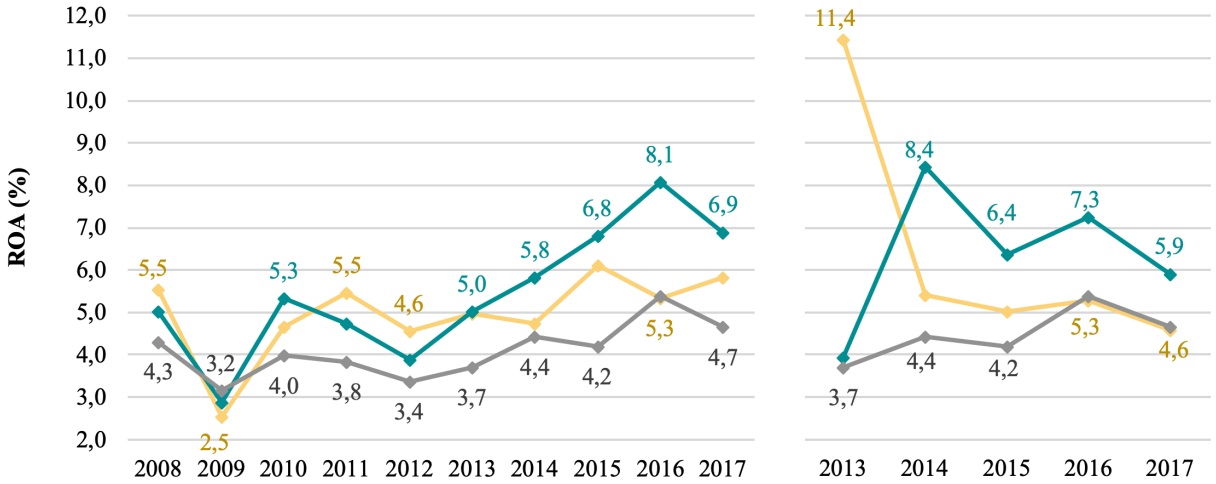
Firms		
	Number	115
	%	52%

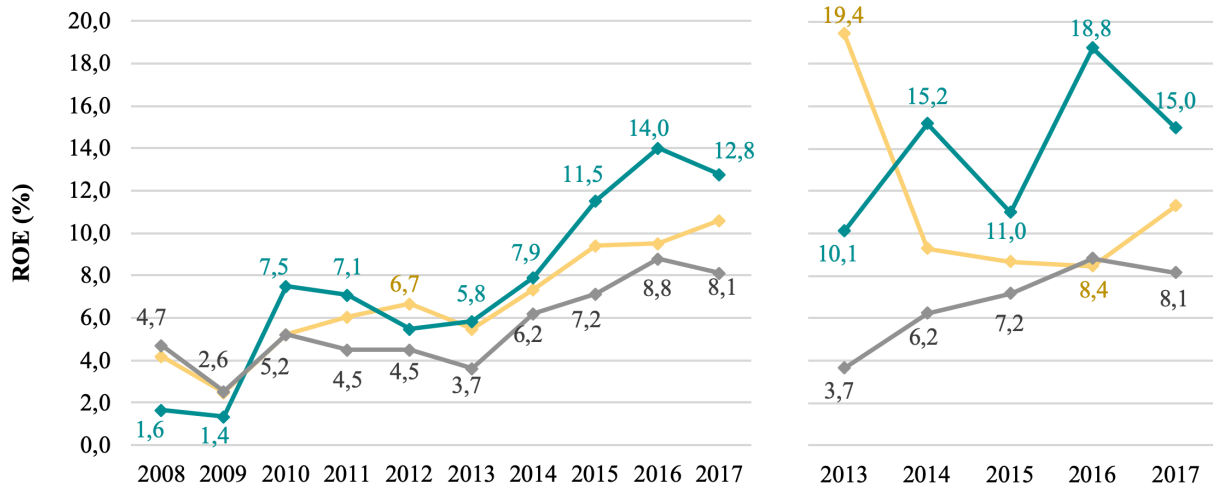
[20] The percentage has been calculated as a ratio between the number of Lean techniques adopted by each firm and the number of Lean techniques adopted by the firm which relies on the highest number of them within the sample. However, the Table shows the presence of two outliers which can skew the classification, thus the companies which implement 86 and 85 Lean techniques. Consequently, the benchmark chosen has been the company which adopts 57 Lean techniques.

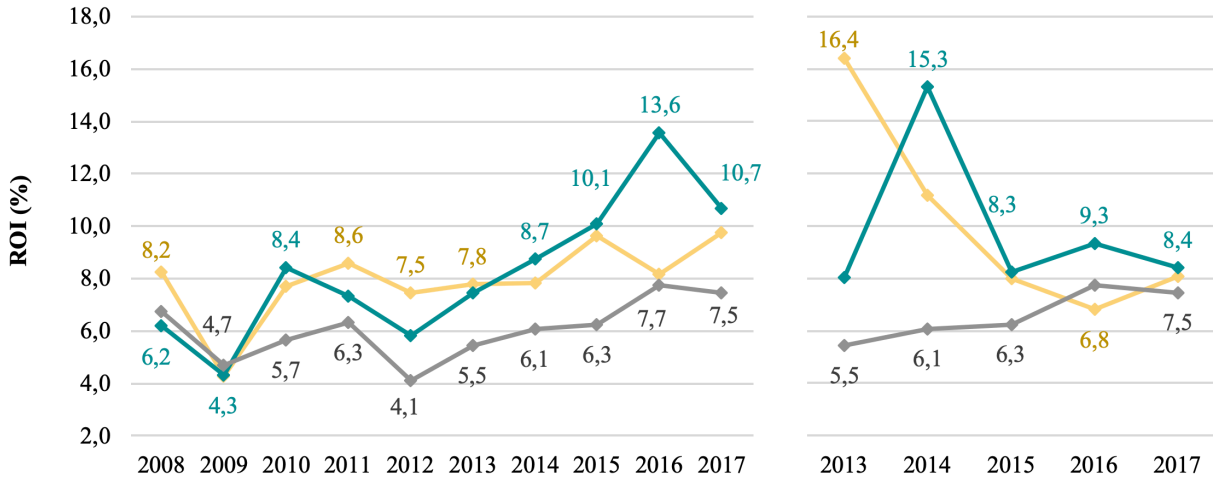
Appendix C: The economic and financial indexes for Beginner and Advanced companies according to their leanness maturity

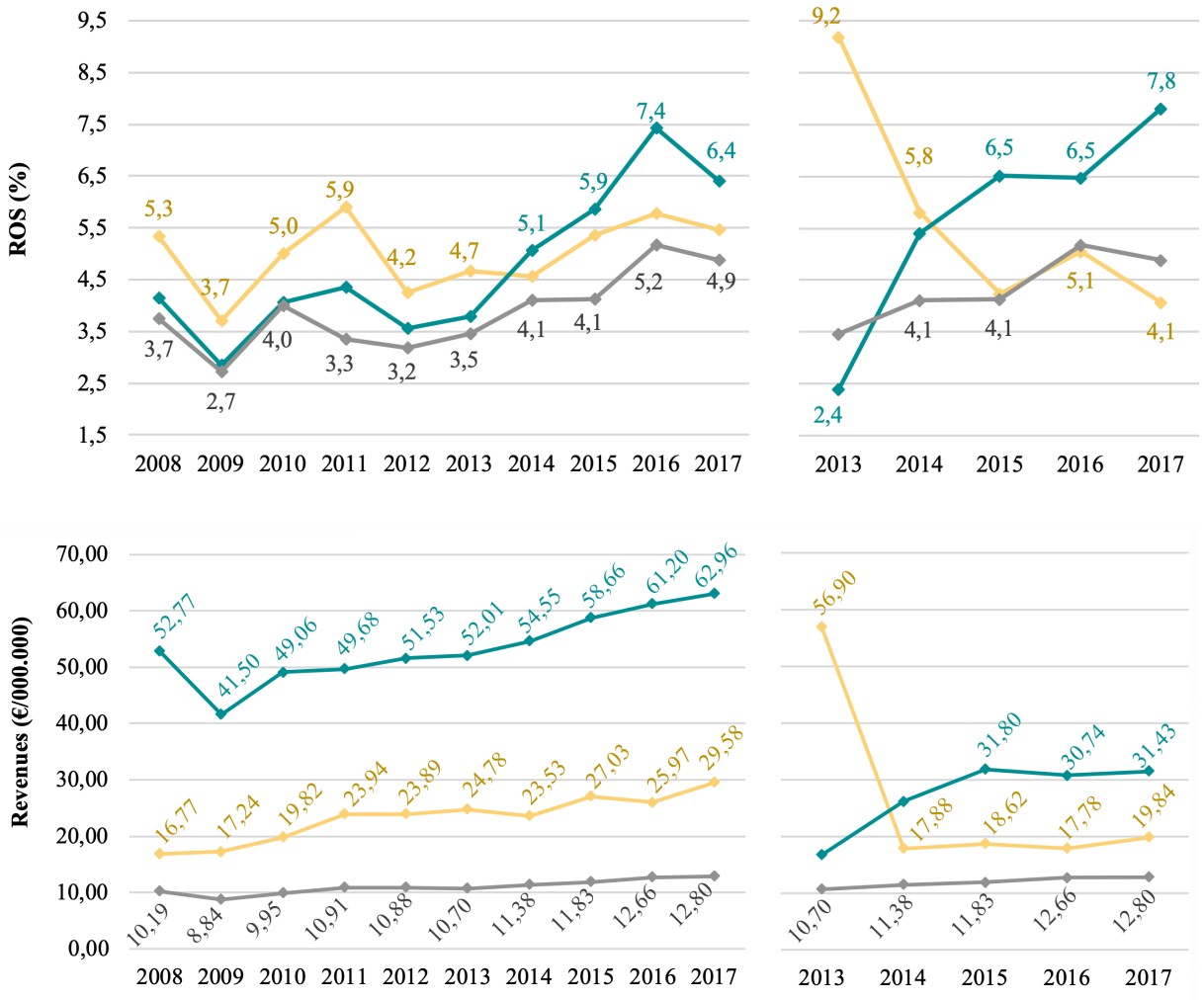
The following graphs show the trend of different economic and financial indexes taking into consideration the median values for each year for each category of companies.




ROA (%)
12,0
11,0
10,0
9,0
8,0
7,0
6,0
5,0
4,0
3,0
2,0
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
5,5 4,3 3,2 2,5 5,3 4,0 5,5 3,8 4,6 3,4 5,0 3,7 5,8 4,4 6,8 4,2 8,1 5,3 6,9 4,7
2013 2014 2015 2016 2017
11,4 3,7 8,4 4,4 6,4 4,2 7,3 5,3 5,9 4,6


ROE (%)
20,0
18,0
16,0
14,0
12,0
10,0
8,0
6,0
4,0
2,0
0,0
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
4,7 1,6 2,6 1,4 7,5 5,2 7,1 4,5 6,7 4,5 5,8 3,7 7,9 6,2 11,5 7,2 14,0 8,8 12,8 8,1
2013 2014 2015 2016 2017
19,4 10,1 15,2 6,2 11,0 7,2 18,8 8,4 15,0 8,1
3,7


ROI (%)
18,0
16,0
14,0
12,0
10,0
8,0
6,0
4,0
2,0
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
8,2 6,2 4,7 4,3 8,4 5,7 8,6 6,3 7,5 4,1 7,8 5,5 8,7 6,1 10,1 6,3 13,6 7,7 10,7 7,5
2013 2014 2015 2016 2017
16,4 5,5 15,3 6,1 8,3 6,3 9,3 6,8 8,4 7,5


ROS (%)
9,5
8,5
7,5
6,5
5,5
4,5
3,5
2,5
1,5
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
5,3 3,7 5,0 5,9 4,2 4,7 5,1 5,9 7,4 6,4
3,7 2,7 4,0 3,3 3,2 3,5 4,1 4,1 5,2 4,9
9,2 5,8 5,1 4,1
2,4 5,4 6,5 6,5 7,8
4,1 4,1 5,2 4,9
2013 2014 2015 2016 2017
Revenues (€/000.000)
70,00
60,00
50,00
40,00
30,00
20,00
10,00
0,00
2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
52,77 41,50 49,06 49,68 51,53 52,01 54,55 58,66 61,20 62,96
16,77 17,24 19,82 23,94 23,89 24,78 23,53 27,03 25,97 29,58
10,19 8,84 9,95 10,91 10,88 10,70 11,38 11,83 12,66 12,80
56,90 17,88 18,62 17,78 19,84
31,80 30,74 31,43
10,70 11,38 11,83 12,66 12,80
2013 2014 2015 2016 2017