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"LEAN BUNDLES AND FINANCIAL PERFORMANCE: ASSESSMENT OF NORTH-EASTERN ITALY MANUFACTURING FIRMS"

RELATORE:

CH.MO PROF. Furlan Andrea

LAUREANDA: Elisa Galzignato

MATRICOLA N. 1140353

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INTRODUCTION

Lean was born within the walls of Toyota in the second half of last century. The lean concept then started to be spread worldwide in the 90s thanks to the book of Womack and Jones *The machine that changed the world*, in which they describe the Toyota Production System as the source of the huge success of Toyota. Since then, a multitude of firms actually adopted it believing in its benefits. Lean manufacturing is nowadays worldwide spread and adopted more or less intensively by countless firms in different sectors. However, not always its implementation brought the expected benefits, and scholars started to investigate the reasons leading to its failure, or even questioning whether it truly brings benefits to organizations. Countless studies investigate the relationship between lean and performance, considering different variables and outcomes, and results are extremely mixed, meaning some demonstrate lean implementation does not improve performance, and some others demonstrate it actually does. This paper is part of this line of research that tries to understand whether, and how, lean positively affects performance. Narrowing our scope, our research question is whether the implementation of technical-oriented and continuous improvement practices in three well defined organizational areas, namely production, logistics, and purchasing, have a positive impact on firms' financial performance, measured as EBITDA/Sales or ROA.

To be able to answer this question, a survey comprehensive of 32 questions about lean management was sent to companies belonging to the manufacturing sector of North-eastern Italy, and a sample of 248 valuable answers was collected. An overview of the sample thus gathered is firstly given, making comparisons between the sample and the overall population of firms in that area, and then breaking down the sample to identify top and worst performers, in the hope of discovering the features firms belonging to these subsamples have in common. In a second stage, an in-depth analysis is carried out through the fsQCA software, that uses the namesake fuzzy sets qualitative comparative analysis (fsQCA) to investigate the relationship between lean implementation and performance. In particular, a distinction between bundles, and between implementation areas, is made, since the goal of this paper is to find out which lean bundles better influence companies' performance.

The paper is structured in the following way: in chapter 1 is provided an overview about lean management, with an explanation of the guiding principles and main tools; chapter 2 contains the literature review, focused mainly on three topics, namely the concept of lean, the different practices and bundles and, finally, the relationship between lean and performance. In chapter 3 is explained the method used, and an overview of the sample is provided, through several

comparisons encompassing different aspects and different subsamples, as for example the comparison between top and top lean, and top and worst performers. Then, chapter 4 contains the detailed analysis made through the fsQCA software, in which technical-oriented and continuous improvement practices are tested to understand their influence on performance when implemented in production, logistics, and purchasing. Finally, results are discussed and conclusions presented.

CHAPTER 1

PRINCIPLES OF LEAN MANAGEMENT

1.1 LEAN DEFINITION

Before talking about lean assessment, we should define what *lean* means for us. More than one name and definition can be found in the literature to describe the same concept, according to the underlying principles that most want to be highlighted. *Lean*, for example, "stresses the elimination of waste, while *just-in-time* (JIT) emphasizes the idea of producing items only when they are needed" (Slack, Brandon-Jones, & Johnston, 2013, p. 466); *lean synchronization* then spotlights the instant alignment with the demand. Another worthy explanation is the one of lean thinking provided by Womack and Jones, who state: "lean thinking is lean because it provides a way to do more and more with less and less –less human effort, less equipment, less time, less space – while coming closer and closer to providing customers with exactly what they want." (Womack & Jones, 2003, p. 15)

All these definitions remark a different facet of the same broad concept that we will, for simplicity, call *lean*. Countless times you may have heard about lean production. Before that, maybe even about *Just-In-Time Inventory Management*. As the authors of *The Machine That Changed the World* (the 1990's pillar book for the spread of lean in western cultures) state "anything that is new is likely to be misunderstood, typically by attempts to explain the new phenomenon in terms of traditional categories and causes." (Womack, Jones, & Roos, 1990, p. 242) The heritage Henry Ford left was totally different from the new principles pursued by Ohno[1] in the transformation of Toyota[2]. And so, when western managers started hearing about the "Toyota way", they misinterpreted what it really was. Thus JIT and *kanban*[3] firstly became merely an "inventory management system" for U.S. and European managers. It then started to be classified as a production system thanks to the spread of the concept of Toyota Production System (TPS). For some companies just represented (and probably still represents)

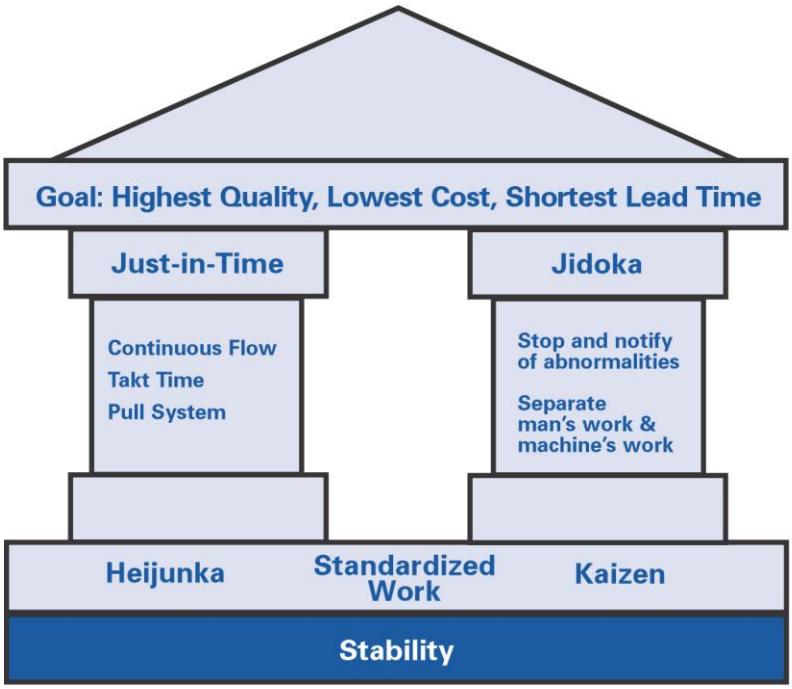
[1] Taiichi Ohno is considered the father of the TPS.

[2] More precisely, the 1914' Henry Ford started with the right foot, sketching a "flow production", but later he got wrong in switching to process villages. So Ohno started from Ford's original idea, making it right where Ford didn't make it (cf. Womack, Jones, & Roos, 1990).

[3] *Kanban* in Japanese means "card" or "signal", and concretely is a small card usually attached to boxes. The functional use will be explained later in this chapter.

"a cost reduction program" (Byrne, 2016). Only around the mid-1980's someone began to puzzle out the incredible success of Toyota: it was deploying a completely different business strategy (Fiume, 2018) and not just a different production system. Indeed, as one can note here below (cf. Figure 1), TPS is much more than a production system. The most popular way of representing it is the 'Toyota Production System House', in which the building blocks are well specified. In particular, JIT and Jidoka are seen as the two pillars of the house, oriented to the same goal of "highest quality, lowest cost, shortest lead time" (Lean Enterprise Institute), sustained by the foundation built of Heijunka, Standardized work, and Kaizen.

Figure 1: Toyota Production System 'House'. Source: Lean Enterprise Institute



Toyota Production System "House".

Hence, what some companies gradually began to understand, is that *lean* was much more. It can be described as a philosophy, that does not stop at production, but rather encompasses several (if not all) steps of the industry value chain, widening from supply to distribution, from provision to consumption, and so from raw materials to the hands of the customer. It should, in other words, "go beyond the firm", rethinking the intra-firms relations in what Womak and Jones call a *lean enterprise* (Womack & Jones, 2003, p. 20-21). What is probably more important to understand, is that *lean* consists of a series of continuous transformations that gradually alter the whole structure of the company; "You can't just add lean on top of a traditional structure and expect success." (Byrne, 2016)

1.2 MAIN FEATURES OF LEAN

Before delineating the five principles necessary to implement a *lean* transition, the foundations over which this theory is built will be illustrated. Three overlapping elements can be identified as cornerstones of *lean:* (1) the elimination of waste, (2) the inclusion of all employees in the process, and (3) the idea of continuous improvement (cf. Slack *et al.*, 2013). Around these pillars then a multitude of tools and other concepts have been developed.

Taking into consideration Ohno's reflection upon mass-production and his first moves in implementing the lean transformation of Toyota, we can already identify a draft of these three elements. One of mass production's principles was to never stop the assembly line, thus errors used to fly under the radar. However, as Ohno rightly noticed, this was multiplying the amount of rectification work needed to be done before shipment, entailing time and costs to rise significantly, not only because detecting a problem at the end of the process was way more troublesome, but also because in this way the same error occurred several times before being solved. What he did to rectify this situation was to give each employee on the assembly line the instruction to stop the line in case of identification of problems. Once the line was halted, the employees were supposed to fix the problem in teams, using a system of problem-solving called *the five-whys*; in other words, errors were not considered 'random events' as in mass-production, but rather employees had the duty to "trace systematically every error back to its ultimate cause" (Womack, Jones, & Roos, 1990, p. 56). Through this set of actions, Ohno put the basis for lean management: (1) eliminate waste of resources (time, money, and people involved in the final rework of the car), (2) involve each employee – all the way down to the lowest level - by giving them the power to stop the line and the duty of problem-solving and, finally, (3) preventing errors to reoccur through the *five-whys* system.

By focusing on waste, to which the Japanese usually refer to as *muda*, and that includes "any human activity which absorbs resources but creates no value" (Womack & Jones, 2003, p. 15), we can actually distinguish three different causes: *muda*, *mura*, and *muri*. Respectively, they relate to an inefficient use of resources, to a lack of consistency, and to absurd or unreasonable requirements. These causes, in turns, bring to seven types of waste: over-production, waiting time, transport, process, inventory, motion, and defectives (cf. Slack *et al.*, 2013).

What can result useful to waste elimination, is the 5s methodology[4], that consists in some 'rules' that aim at keeping the working area as clean as possible, where 'clean' refers to "visual order, organization, cleanliness and standardization" (Slack *et al.*, 2013, p. 484) The

[4] The 5s: Seiri, Seiton, Seiso, Seiketsu, Shitsuke

most popular English translation of the 5S is Sort, Set in order, Shine, Standardize, Sustain. According to Randhawa and Ahuja (2017), the success of the 5S is due to its effectiveness in improving "the level of quality, productivity, organization work culture, employee moral values and safety".

Closely related to waste, is the idea of *gemba*. According to lean philosophy, "the point of production is where value is truly added, not through indirect managerial activities" (Womack *et al.,* 1990, p. 202); that's the reason why, usually, everyone in Japanese lean companies works on the production line for some periods of time, both at the beginning and later on his career; and, that's where the idea of the *gemba walk* comes from: "if you really want to understand something, you go to where it actually takes place." (Slack *et al.*, 2013, p. 472-473) Nothing can actually replace the direct experience.

Switching to the second feature of lean - the inclusion of all staff - it can be useful to report a statement that describes the *truly lean plant*: "it transfers the maximum number of tasks and responsibilities to those workers actually adding value (...) on the line, and it has in place a system for detecting defects that quickly trace every problem, once discovered, to its ultimate cause." (Womack *et al.,* 1990, p. 99) This way of organizing the work has two major implications: a levelling of the hierarchy, by delegating responsibilities down the line and empowering teams, and a new system to communicate the real-time situation to all employees involved in the process. These characteristics of the plant recall some techniques of lean design mentioned in the same book (cf. The Machine That Changed The World, 1990): leadership, teamwork, communication, and simultaneous development, other than visual management practices. Starting from the latter, it is a technique which aims at making everyone aware of the status of the process through the use of simple but effective visual sign, with the function of real-time feedback. By identifying the flow of work and assessing the performance, it gives a snapshot that allows to quick understand if everything is proceeding as planned so that employees are able to promptly solve problems. Coming back to the other four elements just mentioned above, Womack, Jones, and Roos realized that differences in the application of lean techniques in these fields are what makes lean producers take the leap compared to mass producers. What really makes the point in the first three is the role of the *shusa* (in short - the project leader). Major problems in successfully leading projects arise because of a weak figure of the project leader; too often it isn't really seen as a leader to follow, but just as a coordinator to accommodate when needed. The cooperation should be more cross-functional, and less enclosed within departments. Finally, what the *shusa* sometimes does not get, is that it should instigate at the outset the confront of different groups

for the allocation of strategic resources, in order for conflict not to arise later in the development process, which makes it more dangerous, and, above all, makes the number of people involved increasing instead of dropping after the initial phase.

Turning to the third point, the *five whys*, it is a very simple procedure: ask (yourself) five times *why* a problem occurred. Focusing on the 'reason why' of each problem, and going deep in the analysis till the ultimate cause, prevent errors from occurring again. Simply fixing a problem may appear to be the fastest solution, but it can be nothing else than a short-term temporary way of solving it; seizing a problem by the roots allows instead a better performance in the future, leading the number of times it will occur again to drastically fall.

The *five whys* can be framed in the broader context of *Jidoka* ("autonomation", in english), defined as "providing machines and operators the ability to detect when abnormal condition has accurred and immediately stop the work." (Lean Enterprise Institute, *Jidoka*) However, we must specify that Jidoka does not stop at autonomation per se, since it is more about a principle concerning built-in quality. As said before, an ambition of lean manufacturing is to prevent defects to occur in first place, and to reach this objective some tools need to be deployed. The most used ones are *Andon*, *Poka Yoke* (also knew as *mistake-proofing*) and *Six Sigma*. The first two tools consist of devices linked to the production line whose function is to signal the presence of mistakes (usually through a light or a board that enlights) and stop the line, so that any problem can be immediatly solved. Six sigma theory[5] is instead related to the design phase of a product, and it was first developed by Motorola when they understood that "many problems were caused by latent defects, hidden within the design of its products" (Slack *et al.*, 2013) and so difficult or impossible to detect during the production phase. A feasible solution was thereby narrowing the 'allowed' standard deviation of the process for each component.

Strictly connected to Jidoka are the concept of *kaizen* –continuous improvement –and *kaikaku* –radical improvement. The latter is the "bonus released by the initial, radical realignment of the value stream" (Womack & Jones, 2003, p. 27), and by any other major change that will may be made in the future; kaizen is instead what follows kaikaku, and it refers to small improvements made on a continuous base. An useful tool for the deployment of *continuous improvement*, is A3, a method that makes use of a A3-size paper (the origin of the name) for problem-solving. Specifically, people are meant to represent – in a schematic way – suggestions for the solution of a problem in the A3 sheet, that allows in this way both an easy

[5] The Six sigma contains a more wide literature beyond that won't be examined in depth in this paper.

collection of ideas (in some way similar to brainstorming) and an easy sharing of information between people, since it is accessible to everyone.

These concepts and the fifth principle of lean – perfection – as we will see shortly, are mutually reinforcing. What is important to remark about this system, is that standardization is essential; as Ohno himself said: "without standards there can be no kaizen." However what must be remembered is that standardization is never for its own sake, but as a mean for minimizing variability. Managing to have a regular process means that "control becomes visible and transparent to all" (Slack *et al.*, 2013, p. 483) thanks to the fact that is so much easier to identify a deviation from the routine. Both planning and control become in this way simpler to handle.

Other lean practices worth to mention before defininig the five lean principles, are total quality management (TQM) and total productive maintenance (TPM). Often these two practices are mentioned, together with JIT, as the most popular lean bundles (that will be defined in the second chapter). TPM can be defined as "a productive maintenance carried out by all employees through small group activities" (Haddad & Jaaron, 2012) and it aims at guaranteeing that equipments always work, preventing any breakdown to occur and maximizing efficiency; TQM is not far from Quality Management, but it is extended to each area and activity of a firm, and its aim is not far from the general one of lean practices, namely maximize customer satisfaction and minimize defects.

1.3 THE FIVE LEAN PRINCIPLES

Once we defined some main concepts and terminology of lean, we can enunciate the five principles formulated by Womack and Jones (2003) to summarize lean thinking, with the aim of providing guidelines for firms implementing lean.

Principle 1: Specify Value

The first thing that has to be done to implement a really lean transformation is to challenge the traditional definition of value. Too often producers focus on creating value only looking at their point of view, without realizing that customers may have a different perception of what 'value' really is. If you are providing a wrong good or service it is still *muda*, even if you are providing it in the right way. Thus, before thinking about the business model, producers should do a great work 'at the source' by rethinking the current definition of value, to make sure they are offering exactly what customers want. That is the reason why value should be defined in terms of "specific product with specific capabilities at specific prices through a

dialogue with specific customers" (Womack & Jones, 2003, p. 19) instead of defining it just from an organizational perspective.

This first principle has two major implications. First of all, the firm should be built on a product-line basis, and thus should include product teams that follow that specific product during its whole life cycle. Secondly, the manner of determining the target price become now the reverse of the traditional one, meaning that price is set according to the target cost for development –in the hypothetic case all *muda* is removed –instead of just setting a price in line with the market. Once this cost has been determined, the staff works on the process to find out how to actually remove all the *muda*. Clearly, a price gauged in this way will be lower than the average of the market, opening up different possibilities for the firm, like a price reduction, or an increase in the features or a boost in quality, additional services, a network broadening or, finally, reinvesting in new product development (cf. Womack & Jones, 2003).

Principle 2: Identify the Value Stream

The authors identify three "critical management tasks" characterizing every business: *problem-solving*, *information management*, and *physical transformation* (cf. Womack & Jones, 2003). All the actions made to carry out these three tasks delineate the value stream of a firm. Value Stream Mapping (VSM) is "the process of mapping the material and information flows required to coordinate the activities performed by manufacturers, suppliers and distributors to deliver products to customers." (R.Sundara, 2014) The process is made up of two steps. First, a 'current state' map must be drawn. By doing so it will be possible to distinguish three possible types of actions: (1) actions creating value beyond any doubt, (2) actions not creating value but unavoidable at the present conditions, and (3) needless actions not creating value at all. The latter should be eliminated straightaway, and for the previous one should be found a way to make them avoidable to do the same. The second step is indeed to draw a 'future state' map starting from improvement plans. Once identified the value stream, the third principle can be undertaken.

Principle 3: Flow

The principle of flow is the real heart of lean. The objective is to reach a *continuous flow* layout, also called 'single-piece flow', in which no buffer and no stoppages in the process exist. When it comes to production, this means it is generally organized within a single cell, but keep in mind that lean does not stop at production; continuous flow shall be brought to every process taking place within the organization and –as an ultimate step –to the *lean*

enterprise. To achieve this objective, all the boundaries within and outside the firm should be brushed aside, and work practices pondered over once more.

For the implementation of a continuous flow system, two requirements are detectable. The first one is *heijunka*, also referred to as 'level scheduling'. Both *production levelling* –which consists of "smoothing the aggregate level of production" (Womack *et al.*, 1990, p. 295) –and *demand levelling* (through aggressive selling and other techniques) can be carried out for the purpose of maintaining the production rate constant. A way to implement levelled scheduling is through *mixed modelling*, which produces a "repeated mix of outputs" (Slack *et al.*, 2013, p. 484). In other words, the machine does not produce a single product version at time, but rather multiple ones on the same line, following the required volume ratios. This method involves thus an extreme process flexibility. Linked to the flexibility of the process, we find the second requirement of continuous flow: machine changeovers need to be cut down by a remarkable amount, to make it possible for products to really *flow*. To be truly JIT only small amount of parts are manufactured one by another, to allow the production of complementary parts to take place "as soon as the amount already produced is summoned by the next process downstream" (Womack & Jones, 2003, p. 58).

To this purpose, SMED techniques are between the most suitable. SMED stands for Single Minute Exchange of Dies, and represents the process of minimizing changeover or setup time, bringing it down to few minutes (ideally, 9 minutes or less (cf. Lean Manufacturing and Six Sigma Definitions)). The first step to implement this process is to distinguish between internal and external setup tasks –which are, respectively, the work to be done during stoppages, and work that can be done while the machine is running. Once this activity has been performed, the goal is to convert as many activities as possible from internal to external, while at the same time decreasing the amount of time spent on accomplishing internal tasks.

These are the two technical requisites to implement continuous flow system. However, all these tasks are carried out by the workforce, which implies the need for cross-skilled teams, whose work is supported by standardization and Jidoka, ensuring that "proper conditions exist before executing a process step, preventing defects from occurring in the first place" (Poka Yoke or Mistake Proofing :: Overview) and, in the case they occur, allow to fix them in the shortest possible time.

Principle 4: Pull

At this point, if you really managed to implement a continuous flow system, the time required to conclude a cycle should have dropped sharply. This means a *pushing* system is no more suitable, rather it's time to execute the fourth principle: *pull*. Following the philosophy "sell

one; buy one" or "ship one; make one" (cf. Womack & Jones, 2003) is now consumers demand that enact the whole production process, in such a way that it shall always be the step downstream that pull the previous one. No items will be made unless demanded. One way to operationalize pull control is the use of *kanbans* (cf. Slack *et al.*, 2013), which give the signal to move items from one step to the following; unless a kanban arrives at the stage, no unit will be moved.

A crucial concept for the pull principle is the one of *takt time* since it determines the pace of production. Namely, it "precisely synchronize the rate of production to the rate of sales to customers." (Womack & Jones, 2003, p. 55). This does not mean it indicates the amount of time needed to have the final good manufactured, but simply how much time should pass by between the start of one unit and the next one. This allows to have clear in mind the capabilities of the production system and thus to compile a precise order schedule.

Principle 5: Perfection

One of the definitions of lean provided at the outset was about doing "more and more with less and less" (cf. Womack & Jones, 2003). We then talked about *kaizen* and *kaikaku*, and about the fact that lean entails continuous transformations. Indeed, lean means that the process is reviewed over and over again, in a constant challenge of moving closer to perfection at the eyes of the customer, while at the same time reducing the resources needed –effort, time, space –and costs and mistakes. To make this possible, other than applying the four lean principles presented above, one last lean technique is needed: policy deployment. The risk, after having had a good starting phase, is being caught up in the excitement of positive results and selecting outnumbered projects compared to the available resources. Good managers shall instead learn "how to *deselect* projects" (Womack & Jones, 2003, p. 97) through the mean of policy deployment.

One last key element for lean implementation is *transparency*. If perfection wants to be (theoretically) reached, cooperation throughout the whole value chain should be pursued. This recall the Womack and Jones' idea of *lean enterprise* which goes beyond the organizational boundaries. To reach the best possible solution each individual and entity of the industry value chain should make its own contribution. There is just one big problem to reach this state: a joint action of analyzing each firm's cost structure and value creating processes "...makes every firm's cost transparent. *There is no privacy*." (Womack & Jones, 2003, p. 276) This implies taking the decision of which margin each firm is 'allowed' to make, according to industry' opinion. The information asymmetry in the market, however, is likely

to trigger incentives to withhold information from the other players, making a truly lean enterprise more difficult to create.

CHAPTER 2
LITERATURE REVIEW

A literature review will provide a framework to better clarify both the background and the reasons for conducting a lean assessment.

Being the lean theme extremely wide and world spread, we can't expect to find a unique definition nor uniformity in the literature concerning it. Moreover, it is characterized by an exponential –still ongoing– expansion over the last years, factor that makes a clear analysis more complicated.

2.1 THE CONCEPT OF LEAN

The concept of lean took the leap in the 90s, crossing the Japanese borders and reaching a worldwide audience mainly thanks to the work of Womack, Jones, and Roos (1990) in which they used this term to describe the Toyota Production System (TPS) (Holweg, 2006) (Mostafa, Dumraka, & Soltan, 2013). However, the term lean was not coined by them, but rather by Krafcik in his paper *The Triumph of the Lean Production System* (1988), in which he introduced the terms *lean* and *buffered* production systems, respectively referring to Fordism and TPS. Nevertheless, since this same paper, there is not a unique way to refer to lean: it is addressed to with a various terminology comprising *production philosophy*, *production system*, *production management policy*, *operation*. (Krafcik, 1988) Analogously, in the literature authors interpret the lean concept in several ways, spanning from philosophy to manufacturing system, through dynamic learning process (Randhawa & Ahuja, 2017), probably due to the fact that there is not a single agreement on the set of practices constituting lean. Other terms as JIT or TPS are likewise sometimes used as synonyms. We will refer to it with the broadly accepted term of Lean Manufacturing (LM), without necessarily diminishing its possible and potential applications across the various functions of a firm. As Bortolotti *et al.* recognise (2014), there are nowadays two main trends: those who follow LM as a philosophy (e.g. Womack *et al.*,1990) and those who view it from an operational point of view, and so as a set of concrete tools to reduce wastages (e.g. Shah & Ward, 2007).

2.2 PRACTICES AND BUNDLES

As said before, lean is currently undergoing a process of expansion, being applied more and more in different industries and different fields. This implies that a wide variety of

instruments are referred to as lean tools, but different authors have different opinions about which is the core set. A topic upon which there is total agreement are the five lean principles enunciated by Womack and Jones (2003): specifying value, identifying the value stream, flow, pull, and perfection. Another topic generally accepted is that lean is about waste elimination and continuous improvement. But with regards to the bundles of practices to be implemented to reach these objectives, there is a number of different opinions. What emerges is that lean is 'conceptually multifaceted'and its 'underlying elements' (cf. Shah & Ward) are countless. Clearly understanding which are the 'official' practices, or which are the most important, is really difficult, if not impossible, with the currently available instruments. Research, as we will examine later in this chapter, is moving toward an assessment of the interrelation between lean practices and performance, and different bundles of practices are being tested, but results are sometimes still ambiguous. What we know for sure is that none of the lean element can successfully be implemented alone (Shah & Ward, 2007). That's why it makes sense to talk about bundles of practices, where 'bundle' is defined as "a set of interrelated and internally consistent lean practices" (Shah & Ward, 2003). The four most popular bundles are just in time (JIT), total quality management (TQM), total preventive maintenance (TPM), and human resource management (HRM) (Shah & Ward, 2003) (Taj & Morosan, 2011) (Zhu & Lin, 2017), around which several others are developed. Not always, however, HRM is included as a lean bundle; with regard to this issue two trends –probably often overlapping with the above-mentioned ones –can be identified: those who believe HRM is essential for the success of LM (e.g. Furlan, Vinelli & Dal Pont, 2011), and those who don't (Oliver, Delbridget, Jones, & Lowet, 1994). But, as said before, opinions about the practices to be included within each bundle are really different, and probably varying according to the industry and the business strategy.

2.3 LEAN AND PERFORMANCE

A wider part of this chapter will be dedicated to the literature that investigates the correlation between LM and performance, being this topic the heart of this paper. Broadly speaking, results usually support a positive correlation between lean and performance, but several specifications have to be made.

- First of all, not all studies support this theory. We will shortly enunciate factors identified as the source of failure for lean implementation.
- Second, two types of performance can be identified, namely operating performance (OP) and financial/business performance (BP). Furthermore, each one can be calculated in different ways, being the most common –for OP– productivity, quality,

and flexibility (e.g. Krafcik, 1988) and often also delivery (e.g. Bortolotti, Danese, & Boscari, 2014); ROA and ROS for financial performance (Fullerton, McWatters, & Fawson, 2003) (Azadegan, Patel, Zangoueinezhad, & Linderman, 2013). Therefore, assuming different practices can affect different performance indicators in various ways (Cua, McKone-Sweet, & Schroeder, 2001), we have to pay attention in generalizing results.

- Third, being opinions different about which are the main lean bundles, different researchers study the effect of different factors on performance. Some studies provide empirical results limited to the application of just one bundle on performance, Fullerton *et al.* (2003), for example, provide an analysis of the relation between JIT and performance, Anvari *et al.* (2011) of TQM and performance, Randhawa and Ahuja of 5S and performance (2017); other scholars then provide an analysis that encompasses the effects of different bundles, but still considering their singular influence (Belekoukias, Garza-Reyes, & Kumar, 2014); some other studies finally focus their attention on the combined effect of multiple bundles application, e.g. Furlan *et al.,* (2011)
- Lastly, not always lean is found to improve both types of performance. Specifically, operating performance usually improve but financial performance not always; in addition, the debate is whether OP is a 'mediator' of lean improving BP or lean exerts a direct influence on BP.

By analysing the factors that are recognized as often leading to a (partial) failure in the implementation of the lean process, we find that the most mentioned are the ones linked to the 'human element', in particular a poor mindset, a misunderstanding of the lean concept itself (Mostafa *et al.,* 2013) and a lack of employees education. Other scholars, as Fullerton *et al*. (2003) point instead at a lack of management involvement as the source of LM failure. In addition, also a "rigid hierarchical organizational design" (Bamber & Dale, 2010) can create problems, inhibiting employees' participation in the process. The same authors recognize that "a company can only get as lean as its suppliers" (Bamber & Dale, 2010, p. 297), and so, if an organization is not even capable of training its own management and employees, it can't expect lean principles to work across the industry value chain. According to Pavnaskar *et al*. "(T)he misapplications are of three types: use of the wrong tool to solve a problem, use of a single tool to solve all of the problems and use of all tools (same set of tools) on each problem." (Pavnaskar, Gershenson, & Jambekar, 2003, p. 3077) Marvel and Standridge (2009) instead move the focus on the consequences of the misapplication of lean tools,

pointing a reduced confidence in lean as one of the consequences, other than waste in organizational resources.

Another trend in the literature is to point at contextual factors as the source of failure of LM practices. Doolen and Hacker (2005) conducted a specific literature review on the topic and stated that factors as "changing economic conditions, high levels of demand uncertainty, high-mix, low-volume product portfolios, and rigid organizational structures" could have a negative influence on LM. Some scholars indicate instead factors as firm size and firm culture (Shah & Ward, 2007) (Power, Schoenherr, & Samson, 2010) (Azadegan *et al.*, 2013) or firm size and industry type (Lawrence & Hottenstein, 1995) (Jayaram, L.Ahire, & Dreyfus, 2010) and even age and organization ownership structure (Wiengarten, Gimenez, Fynes, & Ferdows, 2015) (Zhu & Lin, 2018). Azadegan *et al.* (2013) recognize also high demand variability as factor weakening lean benefits on performance, due to the higher unpredictability and instability typical of dynamic environments. In a previous study, scholars detected also lower absenteeism, other than stable demand, as a necessary condition for high performance in lean plants (Oliver, Delbridget, Jones, & Lowet, 1994).

Looking at the context from a slightly different perspective, some researchers argue that some LM practices can be influenced also by the cultural environment, particularly distinguishing between individualistic and collectivistic cultures, being lean principles more effective in the latter (Wacker & Kull, 2010) (Bortolotti, 2014) (Zhu & Lin, 2018). Wiengarten *et al*. (2015) furthermore argue that "the negative impact of being situated in an individualistic country" can't be fully offset by trying to adapt the organizational culture.

Turning to the second matter, scholars distinguish the effect of LM on operating performance and on business performance, since different practices impact differently on them. There is, however, a lack of agreement concerning the indicators of either OP and BP. But, if for BP the number stops around five, at least a dozen can be found for OP. The most representative and most mentioned are, namely, quality, cost and flexibility (Taj & Morosan, 2011) (Losonci & Demeter, 2013) (Belekoukias, Garza-Reyes, & Kumar, 2014); Shah and Ward (2007) also recognize quality and cost, but in place of flexibility they indicate delivery, and so do Taj and Morosan (2011) and Zhu and Lin (2017); these last three couples of authors, together with Losonci and Demeter (2013), also sustain cycle time and inventory as indicators. Belekoukias *et al*. (2014) identify instead speed and dependability as substitutes of flexibility. Another relevant factor used to measure OP is productivity (Lawrence & Hottenstein, 1995) (Shah & Ward, 2007) (Fullerton & Wempe, 2009) (Losonci & Demeter, 2013) (Zhu & Lin, 2017). Switching to business performance, the main trend is to

use financial indexes like ROA and ROS (Fullerton *et al.*, 2003) (Shah & Ward, 2007) (Fullerton & Wempe, 2009) (Azadegan *et al.*,2013) (Zhu & Lin, 2017), that reflect that impact of LM on sales and profitability. Sometimes also other financial indicators are used, as ROE, ROI, EBITDA, etc.

Taking a step backward and looking at the lean bundles to be implemented, different schools of thought can be identified. As said above, some researchers stop at the analysis of the effect that a single bundle of practices has on performance. The most investigated is probably JIT (Lawrence & Hottenstein, 1995) (Kinney & Wempe, 2002) (Fullerton *et al.*, 2003) (Taj & Morosan, 2011), but a number of studies cover also the relationship between performance and TQM (Anvari et al.; 2011), or 5s (Randhawa & Ahuja, 2017).

Kinney and Wempe (2002) assert that financial performance improves more thanks to profit margin rather than asset turnover for JIT adopters. They furthermore affirm that for firms that don't meet a certain size threshold, JIT does not improve financial performance. Fullerton *et al.* (2003) investigate the *direct* relationship between JIT and financial performance, by *measuring the degree* of JIT implementation. In their view, the mixed results regarding this relationship are due to the fact that investments return related to JIT implementation are only observable in the medium-to-long term. They argue JIT should improve ROA in at least three ways, specifically by freeing up assets and capital, by lowering inventory levels, and by getting rid of non-value-adding activities, which negatively impact profit margin, all elements that are supposed to increase asset turnover and return on sales (ROS).

Other studies as the one of Belekoukias *et al.* (2014) are dedicated to the analysis and comparison of the effects of different lean bundles or practices on performance. They find, for example, that JIT and autonomation (also known as *jidoka*) have the higher significance in explaining OP (measured in this case as cost, speed, dependability, quality, and flexibility), while TPM and VSM the lower. In the following page, we reported a table (cf. Table 1) draught by the authors about the most common LM tools.

Table 1: Lean manufacturing essential methods and tools. Belekoukias et al., (2014)

JIT	TPM	Autonomation	VSM	Kaizen/CI
Tools: • One piece flow • Pull system • Takt time • Cell manufacturing • Levelled production • Kanban • Visual control Multifunctional employees • JIT purchasing	Tools: • Overall equipment effectiveness (OEE) • Single minute exchange of die (SMED) • 5S • Autonomous maintenance • Planned maintenance • Quality maintenance • Initial control before the starting of the production • Safety and hygiene environment	Tools: • Mistake proofing/ Poka-yoke • Visual control system/Andon • Full Work system	Tools: • Current state map • Future state map • Flow diagrams	Tools: • 5S • Brainstorming • Continuous Flow • Kanban • Datacheck sheet • Five whys • Pareto chart • Run chart • Gantt chart • VSM • Process map • Mistake proofing

The same authors draught another table about previous research of lean impact on organizational performance, that is reported in the appendix (cf. Table 2: Research summary in the area of lean impact on organizational performance). The main contribution of their study is probably finding that kaizen has a modest impact on firm performance, apparently, they argue, for its strategic rather than operational objective; even more surprising were the null impact of TPM and the negative one of VSM on performance.

However, other scholars criticize the kind of studies that consider just the effect of one factor at time, mainly for two reasons: narrow subsets can sometimes lead to erroneous results (Fullerton & Wempe, 2009), and, most importantly, LM potential benefits can't be realized if not implemented as a total system (Nawanir, Teong, & Othman, 2013) (Zhu & Lin, 2018), since the various practices present a high interdependence. Mixed results thus are often caused by a piecemeal adoption of LM practices (Cua *et al.*,2001) and by methodological inconsistencies (Shah & Ward, 2007) (Fullerton & Wempe, 2009). Hence, always more researchers stress the importance of assessing the results of the joint implementation of these practices, providing not only evidence of their 'compatibility' (Cua *et al.*, 2001) or even 'complementarity' (Furlan *et al.*,, 2011), but also that the more LM is carried out, the better the performance (Nawanir *et al.*, 2013) (Belekoukias *et al.*, 2014) thanks to synergies among them (Furlan *et al.*, 2010). Specifically, the integration of TPM, TPS, and JIT lead to superior performance (Hailua, Mengstu, & Hailu, 2018).

A large number of studies focus on the simultaneous implementation of three to four bundles, namely JIT, TQM, TPM, and in some also HRM, and the majority of them prove that the effect on performance is enhanced when they are applied jointly with respect to when only

one program is pursued (Cua *et at.,* 2001) (Taj & Morosan, 2011). At this point two distinctions regarding two issues have to be made: the first concerns the role of HRM, specifically between those who believe HRM bundle significantly contribute to performance, and those who think it is just accessory; the second is about the intermediate role of operating performance. More precisely the issue is whether LM has a direct influence on BP or simply impact BP through OP.

Starting from the latter case, Nawanir *et al.* (2013) test three hypothesis, that are:
H1: LM practices have a positive relationship with OP
H2: LM practices have a positive relationship with BP
H3: OP has a positive relationship with BP
The results they obtain support all the hypothesis, in line with the study of Fullerton and Wempe (2009). In other words, this means that LM practices can impact BP both directly and indirectly, trough OP as mediator.
At this point, a small digression can be made. There is a group of researchers that claims LM have an impact on OP but not on BP (Zhu & Lin, 2018); others demonstrate it does not affect them simultaneously (remembering benefits are only identifiable once LM are applied as a total system). Some others simply stop at proving the impact of LM on OP, not giving anything away about BP (Fullerton & Wempe, 2009).
Going back to the first issue, that is the relevance of HRM, several scholars believe on the importance of its role in nurturing synergies (Taj & Morosan, 2011). Furlan *et al.* (2011), for example, testing the hypothesis of HRM as enhancer of other bundles, reached results suggesting "that HRM is not only an enhancer but an enabler of the complementarity between JIT and TQM" (Furlan *et al.*, 2011, p. 840). They reached this conclusion since they noticed that firms not implementing high HRM didn't show complementarity of the other bundles.

In some way related to this topic, we find the debate about *soft* and *hard* LM practices. "Soft practices concern people and relations, while hard practices refer to LM technical and analytical tools" (Bortolotti *et al.*, 2014). In the appendix is provided a table about soft and hard practices classified by scholars (cf. Table 3: *Hard and Soft LM practices*). What Bortolotti *et al.* (2014) demonstrate in their paper is that what really makes the difference is the adoption of soft LM practices. In fact, they discover there are no notable differences in the implementation of hard practices between successful and unsuccessful lean plants, but there are concerning soft. More specifically, hard practices appear to be more effective when accompanied by soft practices (result supported by Shah and Ward (2007)). Deepening the analysis to understand which organizational culture (OC) profile is theoretically the best, they

identify four dimensions[6] characterizing successful plants: a higher institutional collectivism, future orientation, a humane orientation, and a lower level of assertiveness. The core dimension, however, seems to be the low level of assertiveness, being typical only of lean plants, while the other three factors can be found in generally successful (not necessarily lean) plants.

[6] The cultural dimensions they consider are: Power distance, Institutional collectivism, In-group collectivism, Future orientation, Performance orientation, Gender egalitarianism, Assertiveness, Uncertainty avoidance, Human orientation

CHAPTER 3
SAMPLE DESCRIPTION & DATA ANALYSIS

The aim of this paper is to investigate the relationship between lean bundles and performance, and in particular to test whether different lean bundles affect performance differently. The understanding of which set of practices better influence performance would really be a big help for firms implementing lean. This research stems from Cua *et al*. (2001) study on the joint application of three different lean bundles, namely JIT, TQM, and TPM. To that day, plenty of research had already investigated the effects that lean practices have on performance, but considerations were always made on the individual effect of these bundles. Cua *et al.*, instead, rightly point out that firms are likely to combine different programs, and that these programs are somehow interrelated, so it only makes sense to conduct an analysis that focuses on their joint effect.

To collect data, a survey was created and sent via email to some pre-selected firms. The sample gathered in this way was then screened to eliminate non-valuable or not-complete answers and integrated with financial data downloaded from Aida[7]. In a second phase, results were furthermore elaborated and integrated to conduct analysis using the fsQCA[8] software.

3.1 DATA GATHERING

The starting point of this paper is a survey created by the Lean Observatory of CUOA Business School, in collaboration with the Department of Economics and Management "Marco Fanno" of the University of Padua, currently testing the relationship between lean and performance.

The firms under assessment are those belonging to the manufacturing sector and located in the Northeast of Italy, namely Emilia-Romagna, Friuli-Venezia Giulia, Trentino-Alto Adige, and Veneto. More specifically, the selection of the firms was made through the following scheme: first, the 200,000 most performing companies firms were identified by means of the Aida database, containing financial and non-financial data of Italian firms; secondly, the above

[7] Analisi Informatizzata delle Aziende Italiane (Aida), developed by Bureau van Dijk Electronic Publishing (BvDEP)

[8] Ragin, Charles C. and Sean Davey. 2016. *Fuzzy-Set/Qualitative Comparative Analysis 3.0.* Irvine, California: Department of Sociology, University of California.

mentioned four regions were chosen; then to narrow the focus only ATECO[9] codes within the interval 10-32 were chosen; finally, companies with less than ten employees were eliminated, not to consider micro-enterprises, and the same was done for companies 'in liquidation'.

A survey comprehensive of 32 questions (see Appendix) about the company's features (financial and non-financial) and techniques applied –with the aim of understanding the degree of lean practices implementation– was sent to more or less 2500 companies, and a sample of 248 valuable firms was collected. More financial data were furthermore collected through the Aida database and compared with the overall enterprise population of these four regions, downloaded from the Aida database too. Not considering, also in this case, firms in liquidation, firms with less than ten employees and the ones with financial data not covering at least one of the three years 2015-2017, a sample of 16021 firms was collected, and compared to our smaller sample of 248 firms.

3.2 DATA ANALYSIS

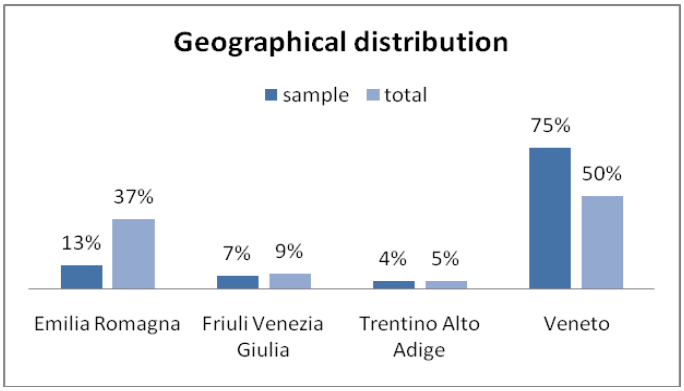
The survey under question was built of two parts: the first one regarding general characteristics of the firm (size, overview, operations, etc.) and the second one concerning the implementation of lean techniques.

3.2.1 SECTION ONE: CHARACTERISTICS

General Information

As one can note in figure 2, from a geographical point of view, the sample is quite over-representative of the Veneto region, and a little under-representative of the Emilia-Romagna region, but perfectly representative for the other two regions. However, most firms of our sample are in Veneto, the region with the higher industrial density among the four (half of the firms are here), so results are reliable.

Figure 2: Geographical distribution [n^s=248; n^x=16021][10]

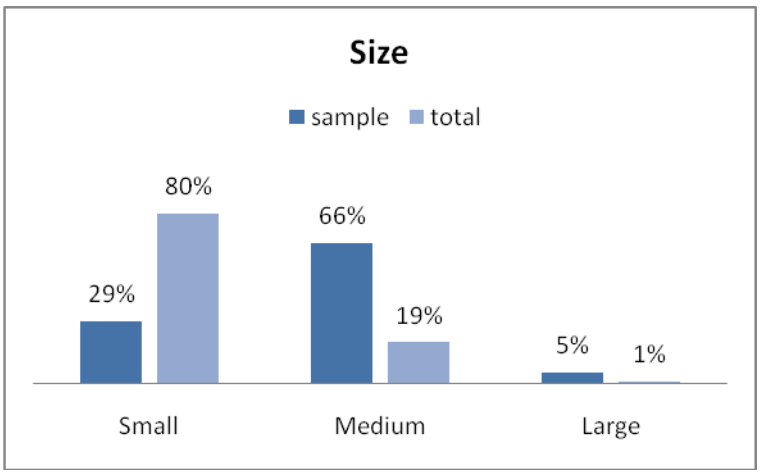


[9] ATECO code is an alpha-numeric classification of Italian business activities.

[10] n^s is referred to the size of the sample collected ; n^x is the number of firms in the four regions

From a dimensional point of view, instead, the sample is way more representative for medium firms with respect to small ones (cf. Figure 3). The latter ones represent the 80% of the enterprises located in the four regions under assessment, however the sample collected only contains 29% of small firms, given also the great willingness of medium ones to answer our survey; big firms are instead well represented. To divide the sample in dimensional classes, the following partition was used: firms with 10 to 49 employees were considered as small (as said above firms with less than ten employees were not taken into consideration); 50 to 499 employees as medium; and 500 or more employees as large.

Figure 3: Companies' Size [n^s=248; n^x=16021]



If then we want to further breakdown medium firms, we can identify as medium-small the ones with 50 to 249 employees, and as medium-large 250 to 499. We can observe that the repartition within our sample between medium-small and medium-large almost perfectly reflects the four region population, and that, in any case, medium-small ones represent around the 90% of the medium firms.

Figure 4: Size (pt.2) [n^s=248; n^x=16021]

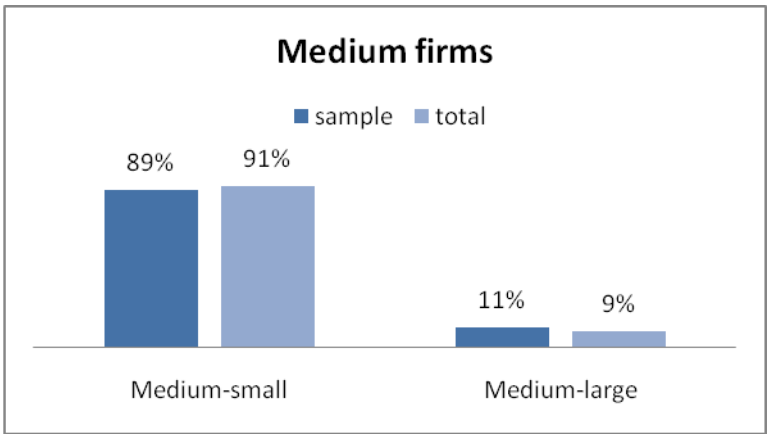
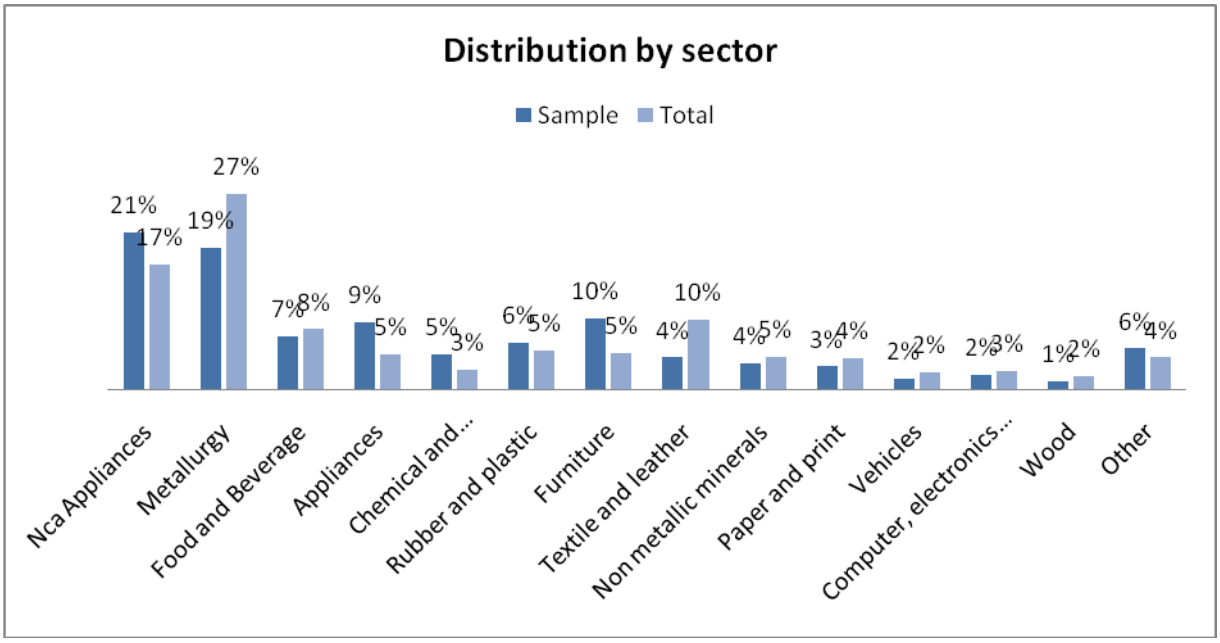


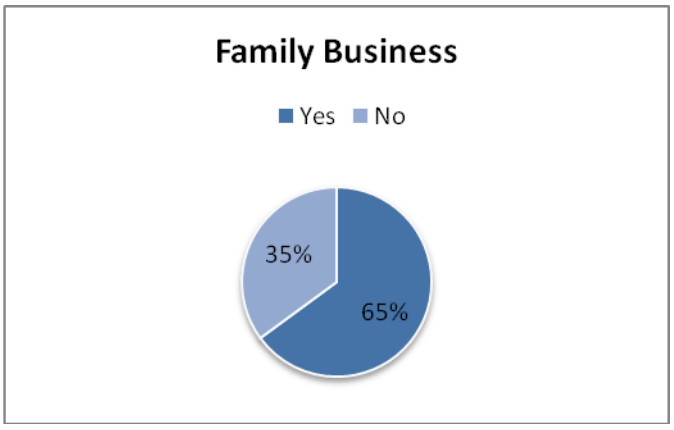
Figure 5: Distribution by sector [n^s=248; n^x=16021]



If we look at figure 5, representing the distribution of data by sector, we can observe that once again the sample is quite representative of the total population. Characterizing sectors using the first two number of the ATECO code, 21 different sectors were identified; the ones with just one or two observations were then grouped in 'others', leading to 14 different sectors. The biggest deviation is on the metallurgy sector, that is also the largest; following, by size, we find the appliances sector. All the others are 10% or below.

Focusing now on the data collected through the survey, we will provide a description of the sample in terms of governance, age of the company, main market and presence of facilities abroad, final customers, productive layout, and industry 4.0. Later, a distinction between lean and non-lean firms –the real hearth of this research –will be provided.

Figure 6: Corporate governance [n^s=248]

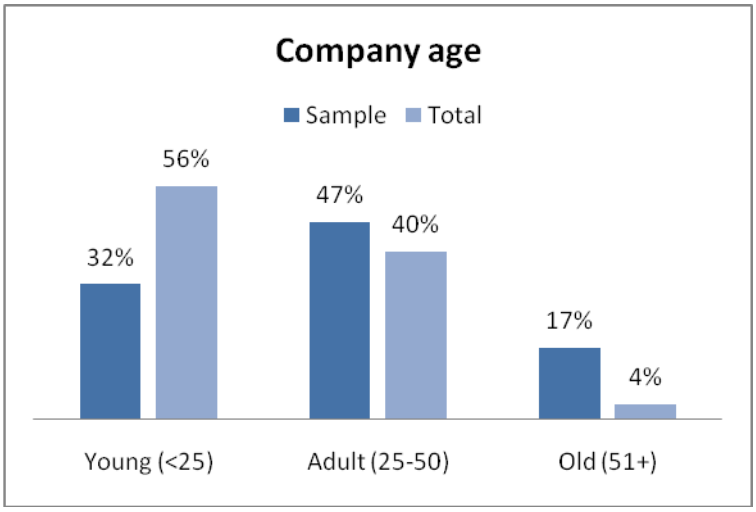


One of the first questions of the survey is whether the enterprise is a family business or not. In the Italian scenario, about 85% of the total firms are estimated to be family businesses, in line

with the European scenario in which the 85% of enterprises are family businesses, and are estimated to account for 70% of the GDP. In the sample collected in this research 'just' 65% are family businesses, but they still represent the big majority.

Another distinction can be done about companies' age, represented in figure 7.

Figure 7: Companies' age.[n^s=248; n^x=16021]



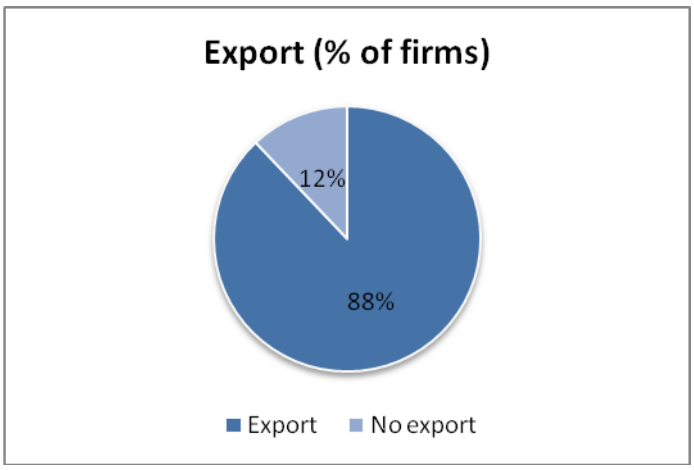
Dividing the sample in three categories of age, respectively *Young* the firms with less than 25 years, *Adult* the ones between 25 and 50 years old, and *Old* the ones with more than 50 years, the sample of 248 companies collected seems to be a little more representative for Adult (47% of the sample versus 40% of the total) and way more for Old (17% vs. 4%) than nor for *Young*, that are instead under-represented (32% in the sample compared to the 56% of the four regions). However, later in this chapter we will provide another distinction based on the number of years of lean implementation, that is way more relevant for our analysis.

Market & Export

Shifting the focus on the market, we can analyse two topics: whether the main market is the national one or not, and where firms produce, to understand if there is a correlation between where most sales are realised and where production physically takes place.

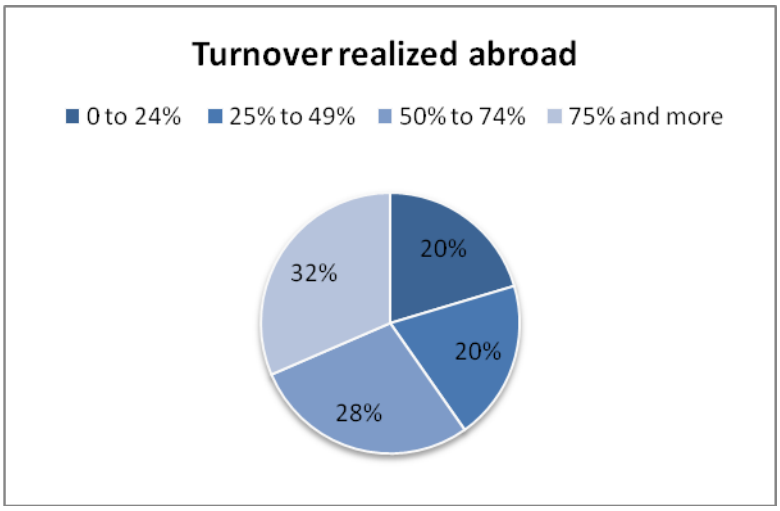
A first step toward this analysis is to first look at whether firms export or not. As one can note in figure 8, the 88% of firms of the sample export.

Figure 8: Export firms[n^s=248]



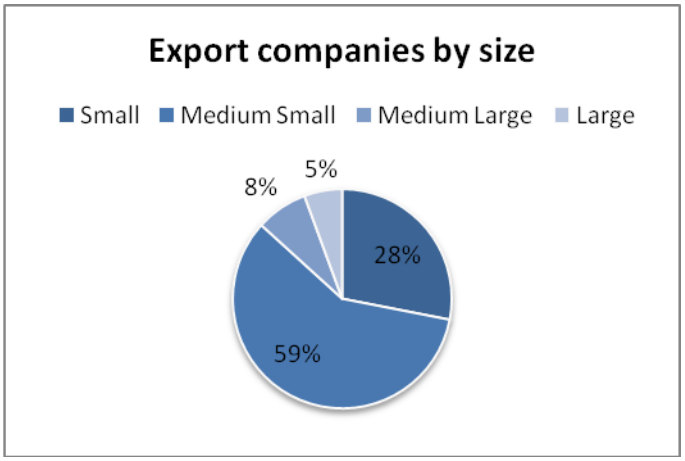
If we deepen the analysis to understand which percentage of the turnover is actually realized abroad (cf. figure 9), we surprisingly notice that, despite the main market is Italy (as we will shortly see), the majority – 60% precisely – realize at least half of its turnover abroad, to be split in 28% realizing between 50% and 74%, and a good 32% that even realize 75% or more of the abroad.

Figure 9: Turnover realized abroad [n^s=248]



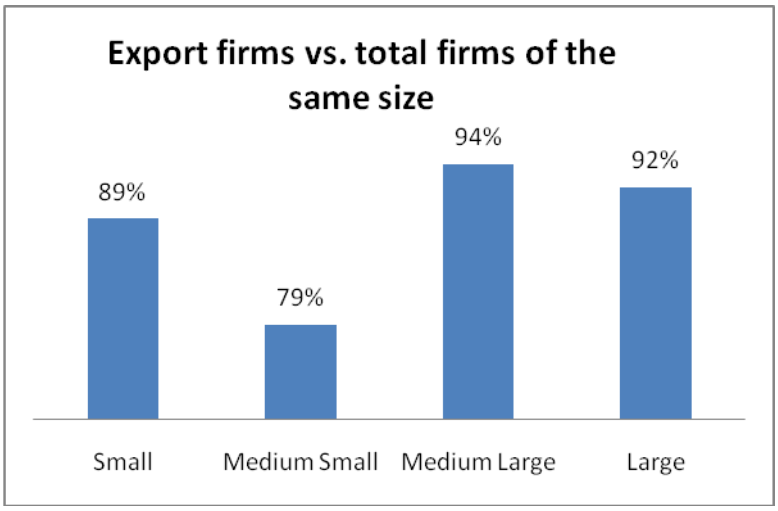
If then we look at which are the main exporters according to their size (cf. figure 10), we observe that small and medium firms of our sample export more than large ones. Medium-small size companies are the main exporters (59%), immediately followed by small ones with 28% of the total export volume.

Figure 10: Export companies by size [n^s=248]



However, an important clarification to be made is relative to the total number of firms: just looking at the composition of export can be misleading. In fact, as figure 11 illustrate, if we take a look at how many firms between the large export, we notice that 92% of them actually do export, being just second to medium-large companies, among which 94% export. The smaller percentage is for medium-small firms (but still at an high level of 79%), that in the previous graph (figure 10) resulted to account for the major component of export companies.

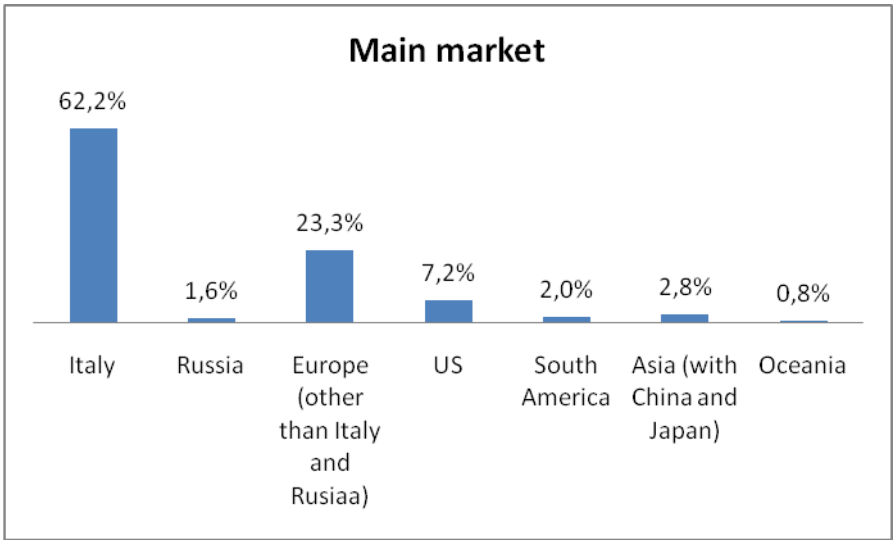
Figure 11: N° of export firms on total number of firms – comparison by size [n^s=248]



We can therefore deduce that the scenario emerging from figure 10 is distorted by the strong presence of medium-small companies in the sample. This is the reason why it is important to analyze the two latter graphs (namely, figures 10 and 11) simultaneously.

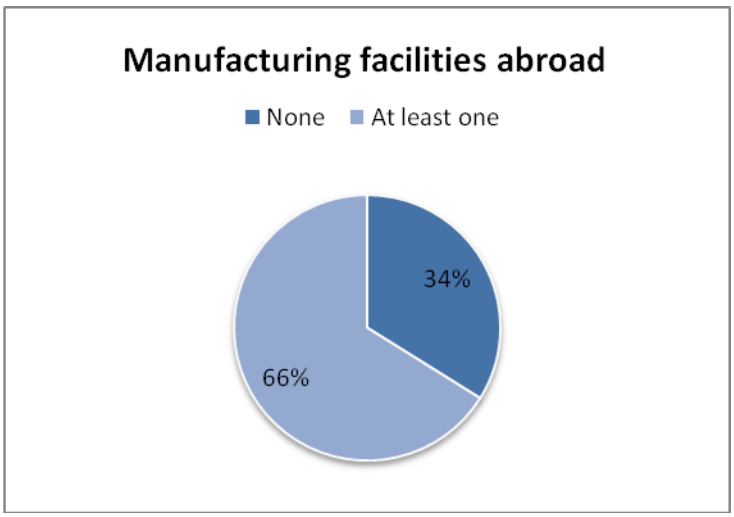
As just mentioned above, for 62.2% of the firms under assessment, Italy represents the main market and, if we consider Europe in general (including Russia), the amount rise to 87%; for around 9% America represents, instead, the main market (7.2% in the US and 2% in Latin America), whereas for the remaining companies the main market is represented mainly by Asian country (as United Arabian Emirates and Iraq, other than China and Japan).

Figure 12: Main market [n^s=248]



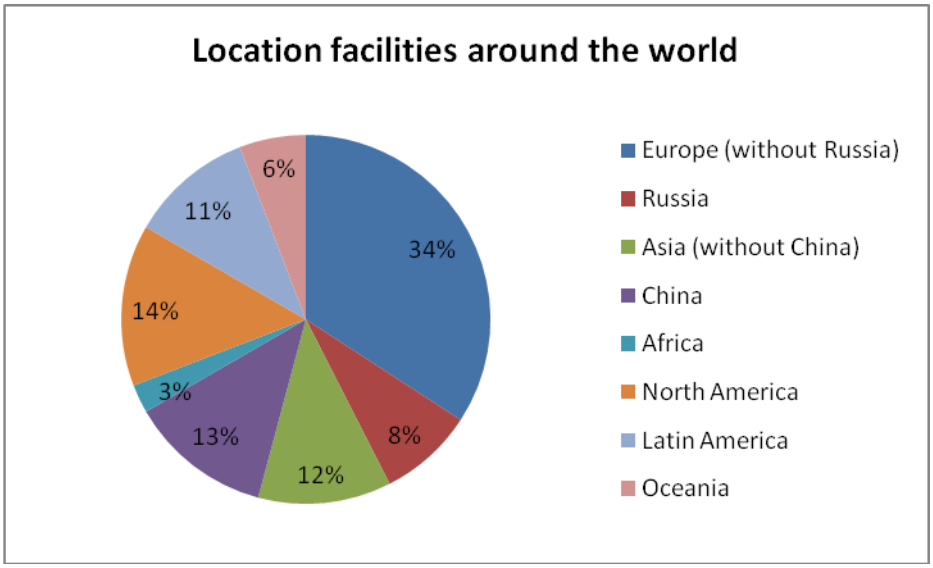
Looking then at where these firms produce, we find out that 34% of them do not have any manufacturing facility abroad, while the remaining 66% have at least one.

Figure 13: Manufacturing facilities abroad [n^s=248]



Deepening the analysis to understand where these facilities are located, the picture that emerges is represented in figure 14: the majority is located in Europe, with the 42% of companies having a manufacturing facility here, 8% of them just in Russia and the remaining 34% in the rest of the continent; after Europe, we find America and Asia with the same percentage, that is 25% each, and respectively sub-divided in 14% in North America and 11% in Latin America, and 13% in China and 12% in the rest of Asia. The remaining 9% is split between Oceania and Africa. From the combination of the last three graphs we can understand that not always production is located in the country corresponding with the main market; in some cases, production facilities are located in a certain country also if the product is not addressed to that country.

Figure 14: Location of production facilities around the world [n^s=248]

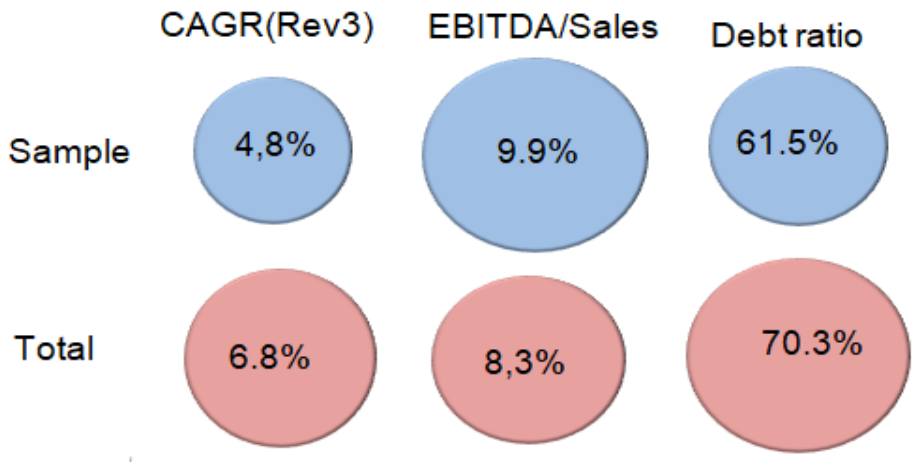


Financial indexes

To describe the sample three financial indexes has been chosen, namely CAGR on revenues, EBITDA/Sales, and Debt ratio. CAGR stands for 'Compound Annual Growth Rate' and represents the mean annual growth rate over a certain period of time. It is calculated as $\left(\frac{Ending\ Value}{Beginning\ Value}\right)^{\left(\frac{1}{\#\ of\ years}\right)} - 1$, and it has been calculated on revenues of the last three years; EBITDA stands for Earnings Before Interests Taxes Depreciation and Amortizations, and EBITDA/Sales is a ratio commonly used to assess companies' profitability (from the comparison between revenues and earnings); The debt ratio is here calculated as $1 - \frac{1}{mean(leverage\ ratio\ last\ three\ years)}$.

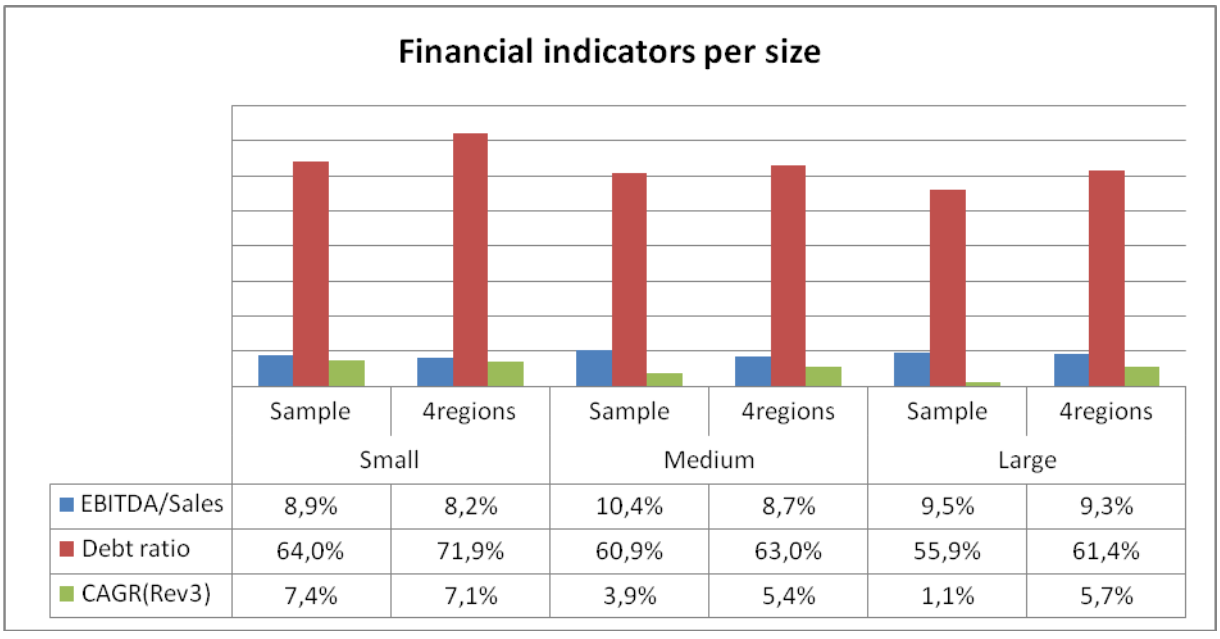
These indexes have been used to understand the representativeness of the sample compared to the overall population of the four regions, to identify the *Top* performers and *Worst* performers among the others in the sample, and to compare lean and non-lean firms with regards to their performance. The two latter analysis will be conducted in the following pages, whereas the picture that emerges from the comparison of the sample and the four regions is reported in the next page in figure 15. For CAGR and Debt ratio, the indexes are lower for the sample, whereas the EBITDA/Sales is higher. The salient point of this research is, however, the comparison of these indicators between lean and non-lean companies, to understand whether lean implementation has a positive impact on them.

Figure 15: Financial indexes.[n^s=248; n^x=16021]



A further breakdown can be conducted with the aim of highlighting how size affects these indexes, and if the sample is coherent with the overall set. If we look at the total, large firms result to be the most efficient according to both EBITDA/Sales (9.3%, compared to 8.7% of medium and 8.2% of small ones) and Debt ratio (61.4% lower than the 63% of medium and 71.9% of small); there biggest difference is in the gap between small and medium, and not really in the medium-to-big gap; with regards to the CAGR on revenues instead the trend is the opposite, with small firms resulting to be the best performers (7.1% against the 5.4% and 5.7%). The same trend is reflected in the sample of 248 firms, with the only difference that EBITDA/Sales index is in this case better for medium firms than not for large ones (10.4% vs. 9.5%), and that CAGR of large firms is under-representative (probably due to the scarcity of answer received from large firms). (For a graphical representation check figure 16).

Figure 16: Financial indexes per size .[n^s=248; n^x=16021]

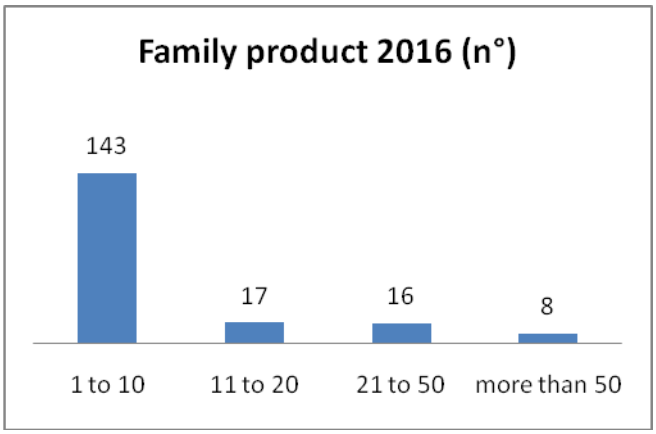


	Small		Medium		Large	
	Sample	4regions	Sample	4regions	Sample	4regions
EBITDA/Sales	8,9%	8,2%	10,4%	8,7%	9,5%	9,3%
Debt ratio	64,0%	71,9%	60,9%	63,0%	55,9%	61,4%
CAGR(Rev3)	7,4%	7,1%	3,9%	5,4%	1,1%	5,7%

Production

Another question of the survey was about the number of different product families that were produced in 2016. The definition of product family given to respondents was “a group of products manufactured through a similar production process and by the same machines”.

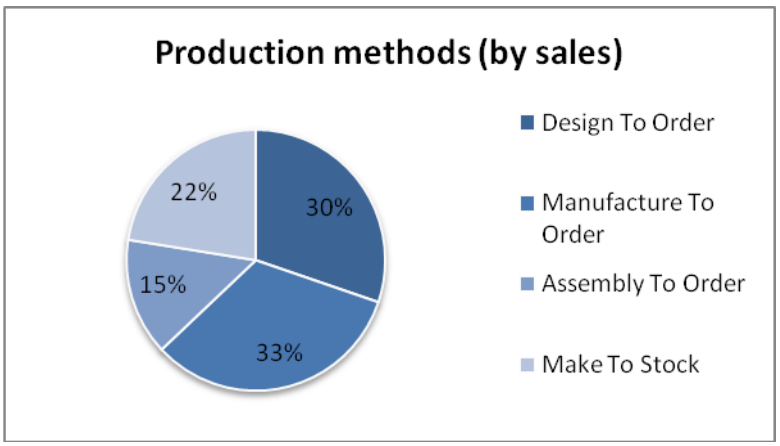
Figure 17: Product families (2016) .[n^s=248]



Unfortunately, not all the firms gave an answer to this question, but the numbers collected were the ones represented in figure 17, with the big majority producing up to 10 product families.

The following question was about the methods of production. In particular, it was asked which percentage of sales was realised through the following methods: Design To Order (DTO), Manufacture To Order (or Make To Order (MTO)), Assembly To Order (ATO), and Make To Stock (MTS). Make To Order is a manufacturing process in which the production phase starts only once an order is received and it is what characterizes pull production (one of the cornerstone of lean manufacturing). A variation of MTO is Design To Order (also known as Engineer To Order), in which the whole design process is made by following customers requirements, and so it is typical of products characterized by high specificity; a ‘downstream’ variation is instead Assembly To Order, in which just the assembly phase is done after the customer places the order. Finally, Make To Stock can be defined as the ‘traditional’ way of conducting the production strategy, so by producing according to sales forecasts, and it implies the presence of inventory (exactly what lean aims at minimize).

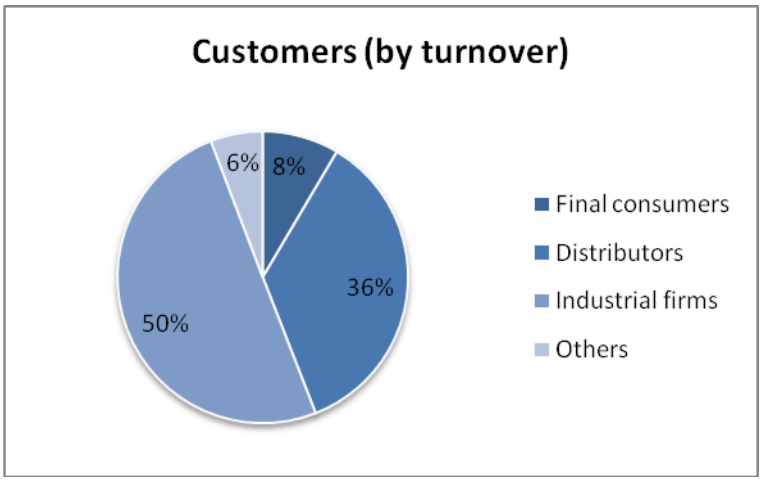
Figure 18: Production methods (by sales)[n^s=248]



Looking at the sample collected for this research (cf. figure 18), the highest percentage of sales is realized through MTO and almost likewise through DTO (respectively, 33% and 30%). The lowest percentage is instead on average realised through the ATO method.

A factor that can hypothetically influence the production strategy is the type of customer to which the product is addressed to (other than, of course, the type of product). Thus, respondent were asked to indicate the percentage of turnover realised for each category of customer, namely final customers, distributors, industrial firms, or others. Answers – represented in figure 19 –indicate that, on average, half of the 2016 turnover was realised by sales to industrial businesses, followed by distributors with a 36% of the turnover; finally, sales to final customers accounted only for an 8%.

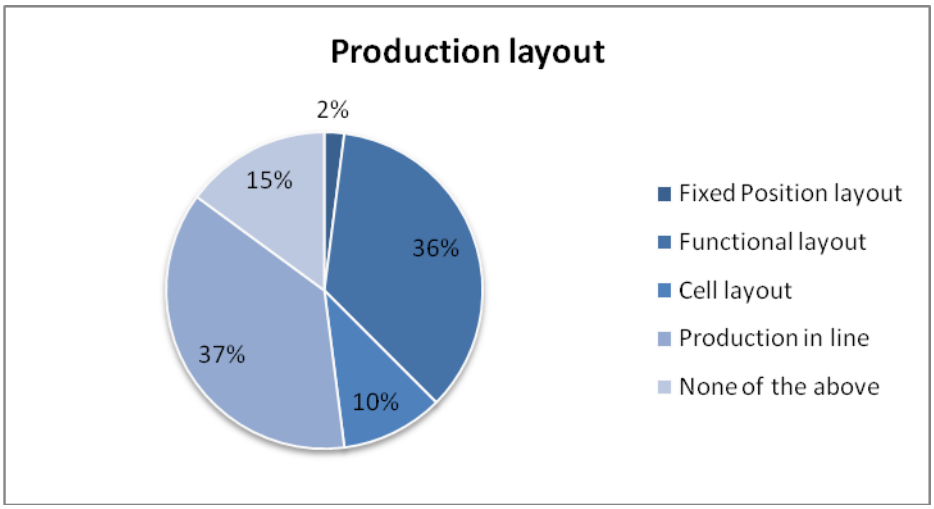
Figure 19: Type of customers (by turnover) [n^s=248]



Another question concerned the production layout used. Joint winners (with little more than 1% difference) resulted production in line and functional layout, that together account for 78% of the 248 firms under assessment. In 10% cases a cell layout is adopted, and only a 2%

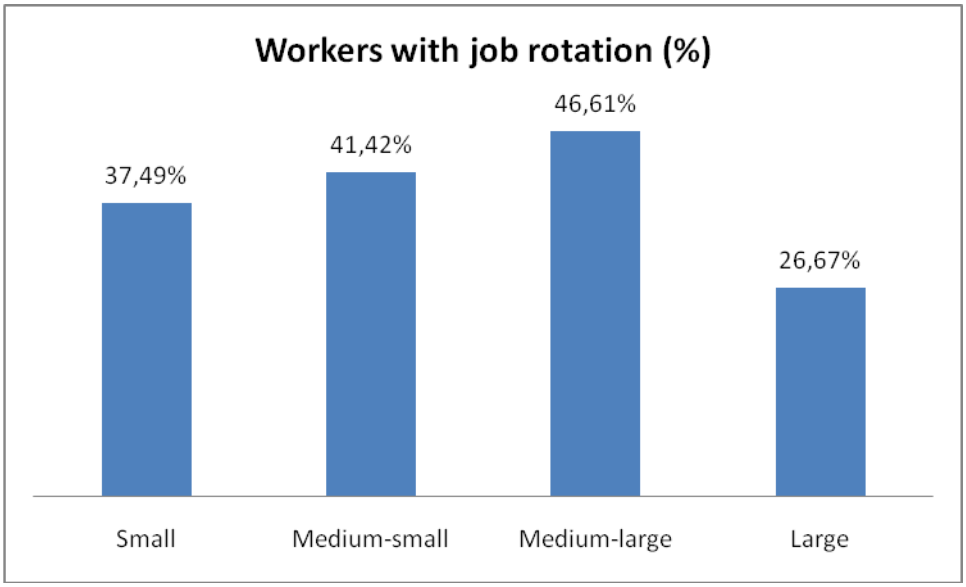
adopt the fixed position layout, that results out-of-date. A 15% of the sample use instead other (non specified) techniques.

Figure 20: Type of production layout [n^s=248]



Going back to the first question of the survey about production, it concerned the amount of employees able to work in more than one workstation. Answers ranged from 0 (20% of cases) to 100% (6% of cases), with the average being around 40% and the median at 30%. If we then breakdown results according to companies size, the higher percentage was found in medium-size firms (almost 42% of employees), followed by small firms with a 4.5% less. The lower number of workers with job rotation was instead noted in big firms, where the percentage stops at 26.7%

Figure 21: percentage of workers with job rotation [n^s=248]

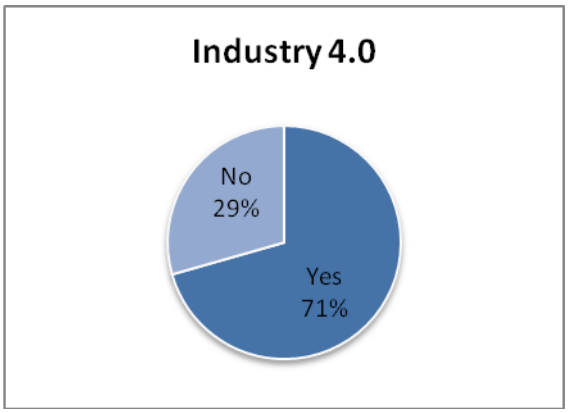


Industry 4.0

The last question before moving on to the second section of the survey was about industry 4.0. This term "stands for the fourth industrial revolution which is defined as a new level of organization and control over the entire value chain of the life cycle of products (...)" (Vaidya, Ambad, & Bhosle, 2018). It includes several concepts as Cyber-Physical Systems (CPS), the Internet of Things, the Internet of Services (Almada-Lobo, 2015), and many others, and is geared towards automation and real-time data monitoring, with the aim of constructing "an open, smart manufacturing platform for industrial-networked information application" Vaidya et al. (2018). [11]

The question asked which techologies, among a specified list, were applied in the firm. The mentioned 4.0 technologies were: robot in production, additional manufacturing, laser cutting, big data, scanner 3D, augmented reality, and internet of things; alternatively, the last box had to be ticked in case none of these technologies were applied.

Figure 22: industry 4.0 [n^i=68][12]

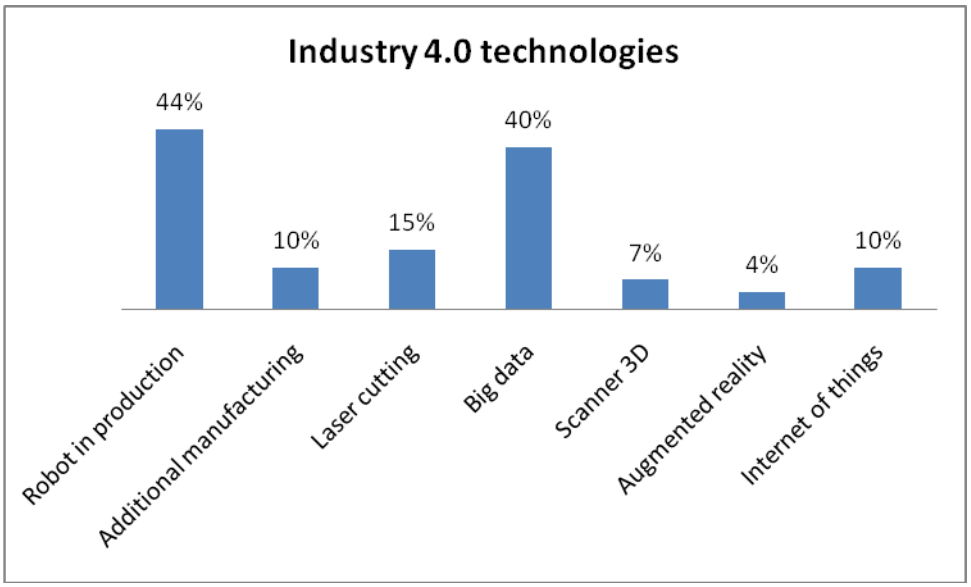


This question revealed the following scenario: overall, 71% of the companies implement at least one of the above mentioned 4.0 technologies. If we then take a look at which are the most popular technologies, we find the use of robot in production (44%) and of big data (40%) at the top, followed by laser cutting in the 15% of cases; the others –namely additional manufacruting, internet of things, scanner 3D and augmented reality –individually amount for 10% or less.

[11] For a quick glance about the topic: Vaidya, S., Ambad, P., & Bhosle, S. (2018). Industry 4.0 - A Glimpse. *Procedia Manufacturing* (20), pp. 233-238.

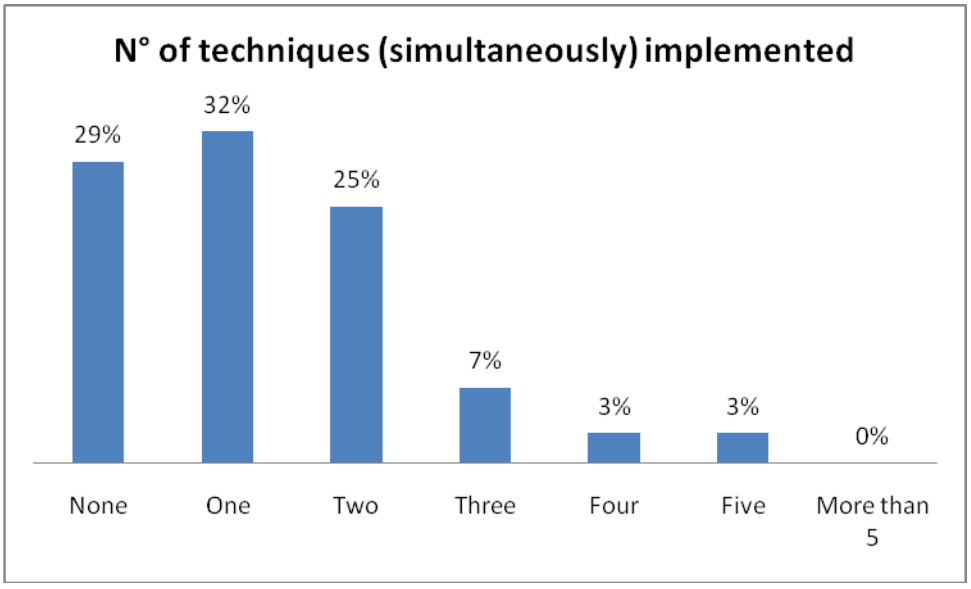
[12] n^i is the size of the sample that answered questions concerning industry 4.0.

Figure 23: industry 4.0 technologies [n^i =68]



A possible breakdown is to look at how many technologies are on average implemented simultaneously, with a maximum of 5 registered, and with just one technology being the most diffused (for 32% of firms). Two technologies are implemented together in the 25% of cases, being robot in production and big data the more frequent combination (20% of cases). Switching to three technologies simultaneously, the number exponentially drops.

Figure 24: number of 4.0 techniques simultaneously implemented [n^i =68]

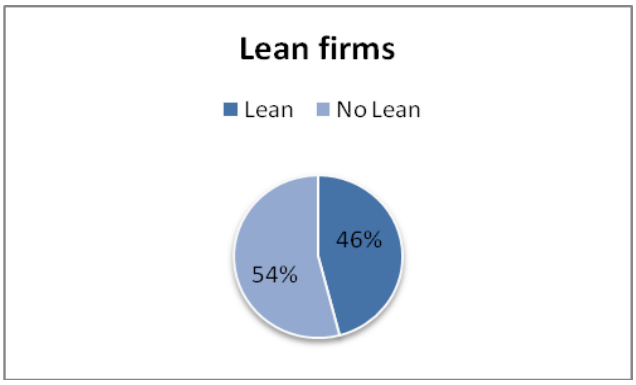


3.2.2 SECTION TWO: LEAN

The second section of the survey was dedicated to lean implementation. The first question of this section asked to give a *Yes* or *No* answer to the question: "Do you apply any lean technique?".

What emerged, is that of the 248 firms, 114 can be defined *lean enterprises* –meaning that they apply at least one lean technique –representing the 46% of the sample.

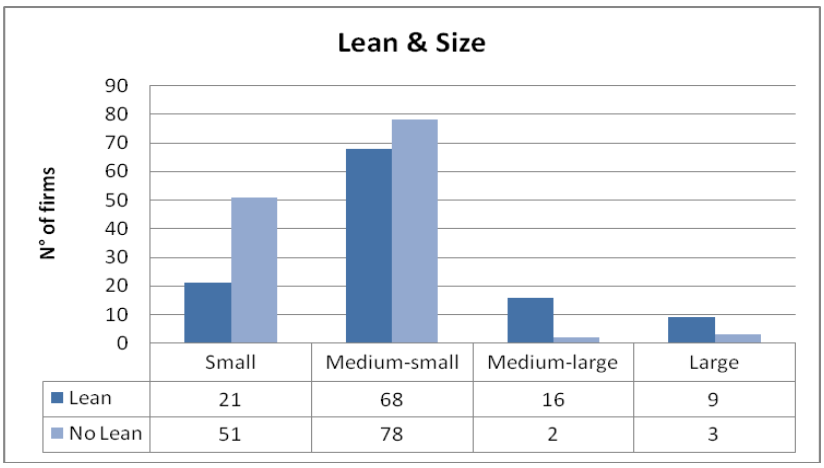
Figure 25: Lean firms[n^{l}=114 ; $n^{y/}$=134] [13]



	Lean	No Lean	Tot
N°	114	134	248
%	46%	54%	

Analysing the composition of the group of lean enterprises, we observe that for large and medium-large size companies (so companies with 250 and more employees) lean outnumber non-lean firms, whereas for small and medium-small ones the trend is the opposite; for medium-small companies the gap is not so big (68 lean vs. 78 non-lean), but for small size the gap is way higher, being small firms more rarely lean.

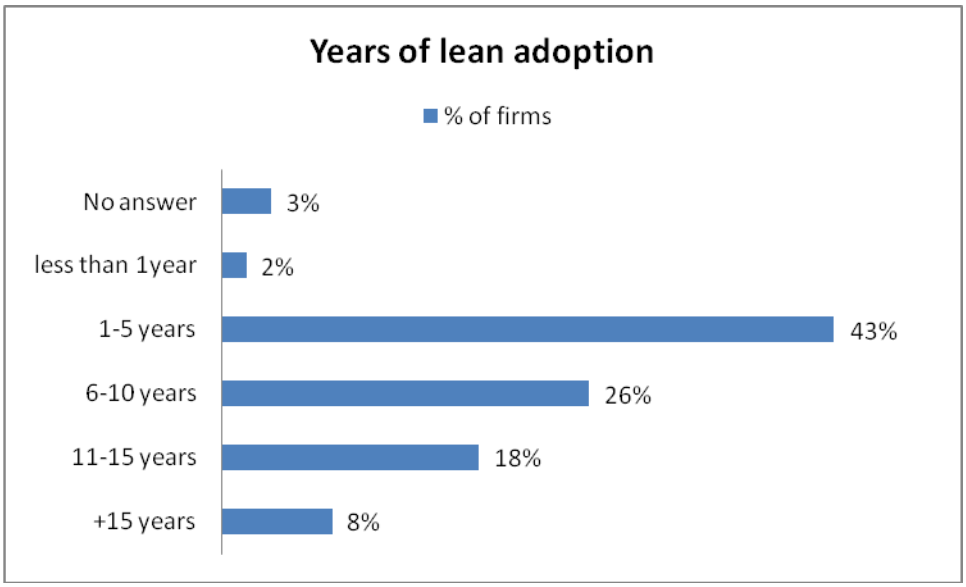
Figure 26: lean firms per size[n^{l}=114]



[13] *n^{l} is the sample size of lean firms; $n^{y/}$ is the number of non lean firms*

For participants who answered *No* to this first question the survey was over. Conversely, if the answer was *Yes*, 16 more questions about lean implementation followed. The second one (always talking about the second section) aimed at identify the year in which lean was firstly implemented. We can see that 43% of companies falls under the category 1 to 5 years, and the next 26% within the 6 to 10 years; the remaining started lean more than 10 years ago, with the exception of two, which just started in 2018.

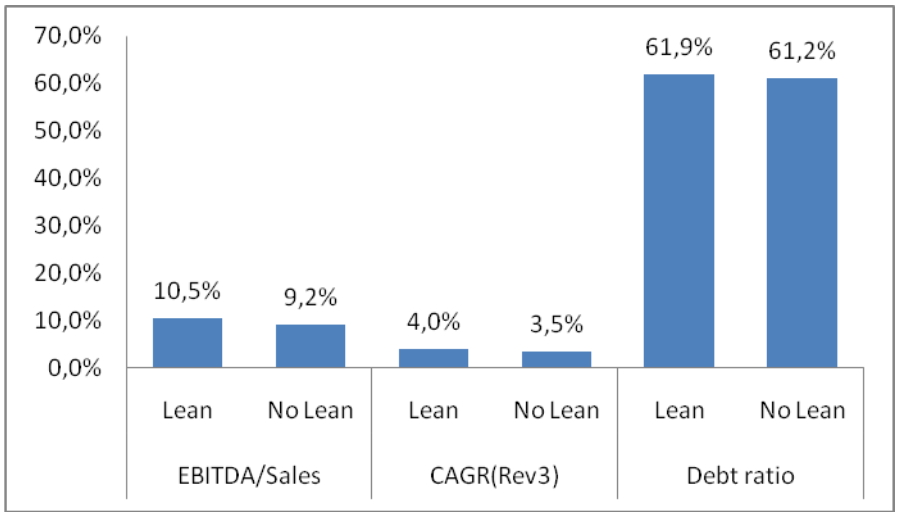
Figure 27: years of lean adoption [n'=114]



For our analysis, the year of lean implementation was a *must do* question, since it can be a determinant in the assessment of lean impact on performance. Intuitively, results won't be evident in the very short-term, but some years can be necessary for benefits to show up. As we will explain in the next chapter, for the fsQCA analysis, firms that started implementing lean after 2014 were eliminated from the sample, because the influence on financial indicators may not yet shown up.

However, from a quick comparison of the three financial indexes of lean and non-lean companies, we can observe that lean on average performs better, also if the difference is not so big. The bigger gap concerns the EBITDA/Sales index, on which lean firms outperform (on average) non-lean ones of 1.3 percentage points. With regards to CAGR on revenues, lean outperform non-lean of 0.5%, and of 0.7% for debt ratio. The difference is observable, but no so marked.

Figure 28: financial indexes comparison [n^{l}=114 ; n^{nl}=134]



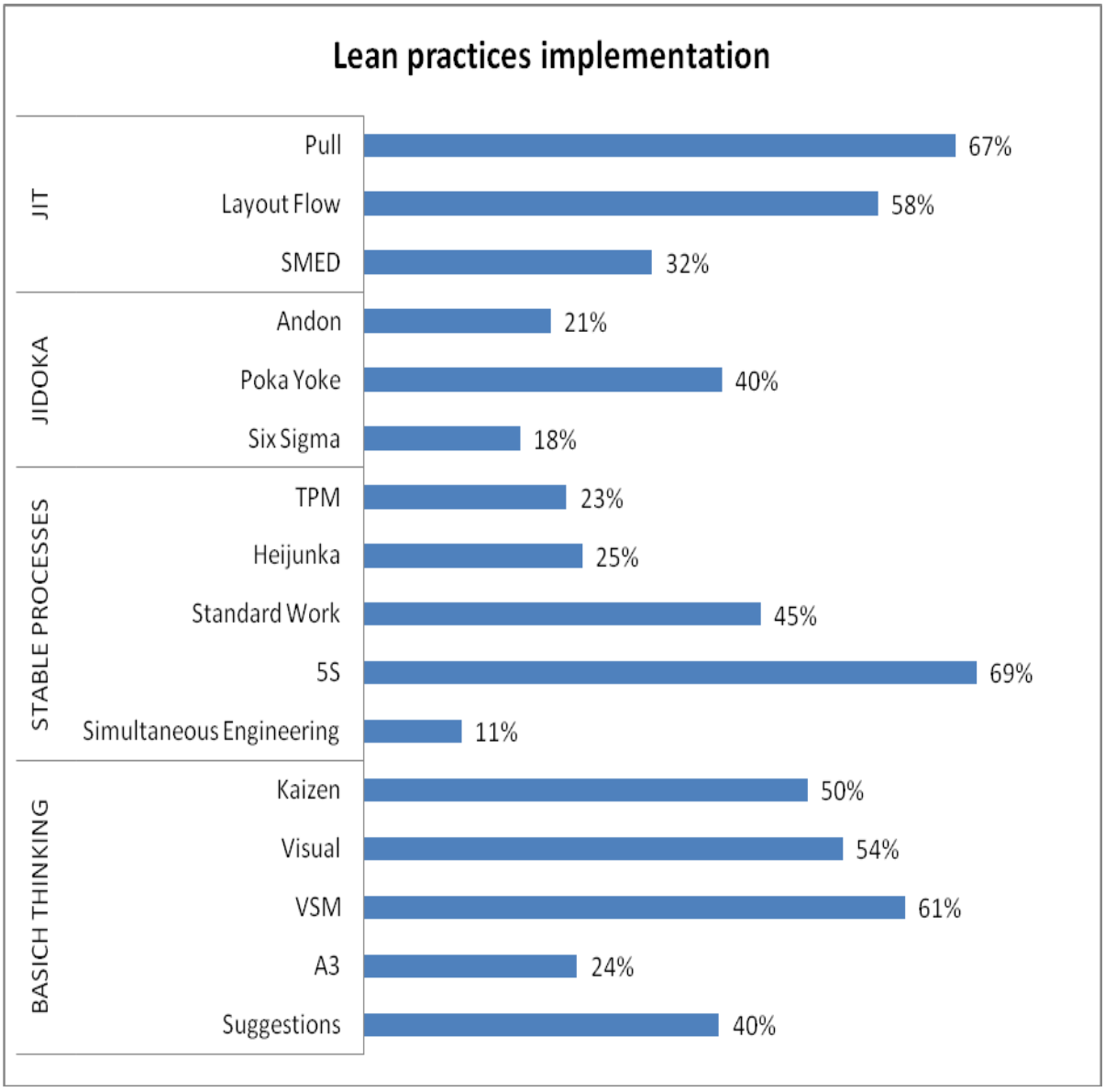
The key link this research is investigating is the one between financial performance and lean implementation. Here below the several lean practices are represented in 'bundles', namely *Just-In-Time*, *Jidoka*, *Stable Processes*, and *Basic Thinking*, and for each practice is indicated the percentage of adoption. The survey asked to indicate which practice[14] was used in which organizational area[15]. The cut-off used to say whether a practice is implemented or not is done simply by looking at if that practice is applied in at least one area; the same goes for the organizational areas: lean is implemented in a certain area if at least one of the practices is implemented there.

If we focus on the individual practices, as you can see in the graph here besides (Figure 29), the top two for implementation are, respectively, 5S –implemented by 69% of firms –and Pull (67%), followed by VSM (61%), and layout flow with 58%. Belonging to the basic thinking bundle (also called *Continuous improvement*) also visual management and kaizen are applied by more or less half of the firms under assessment – 54% for visual and 50% for kaizen precisely. It follows standard work with 45%, and poka yoke and suggestions with 40%. All the others are around the range 20-30%, with the exception of simultaneous engineering, resulting the least implemented with only 11% of firms.

[14] The practices mentioned were: pull, layout flow, SMED, andon, poka yoke, six sigma, TPM, heijunka, standard work, 5S, simultaneous engineering, kaizen, visual, VSM, a3, suggestions

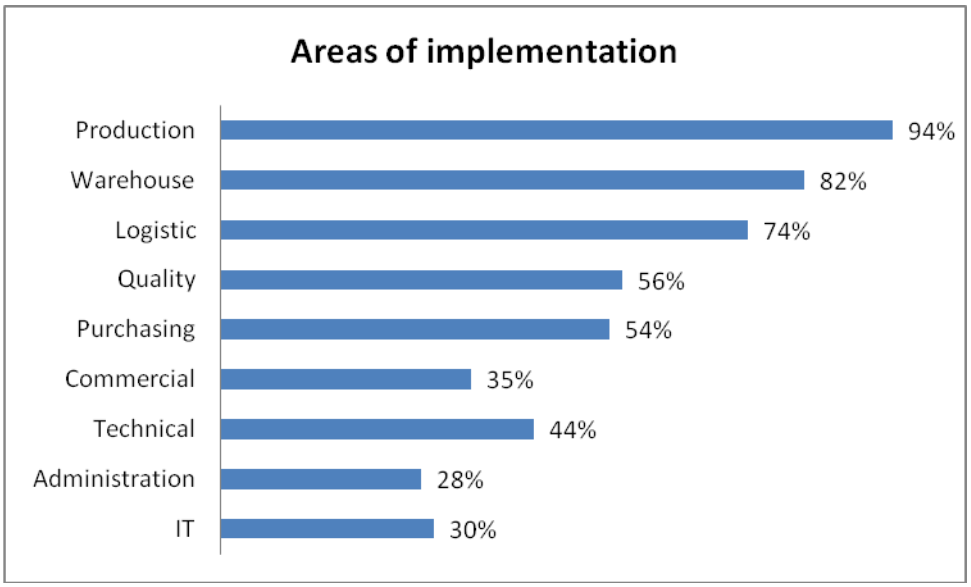
[15] The areas mentioned were: Production, warehouse, logistic, quality, purchasing, commercial, technical, administration, IT

Figure 29: Lean practices implementation [n[1]=114]



Moving to the areas of lean implementation, as one can expect, lean techniques are almost always (94%) applied in production, and a vast majority also does in warehouse (82%) and logistic (74%). These three areas are sometimes considered together as "extended production". More than half of the lean companies also apply lean in quality (56%) and purchasing (54%). The technical office does not reach these numbers, but still amount for a 44% of cases; commercial, IT and administration are instead the areas in which lean is least implemented.

Figure 30: areas of lean implementation [n^{l}=114]

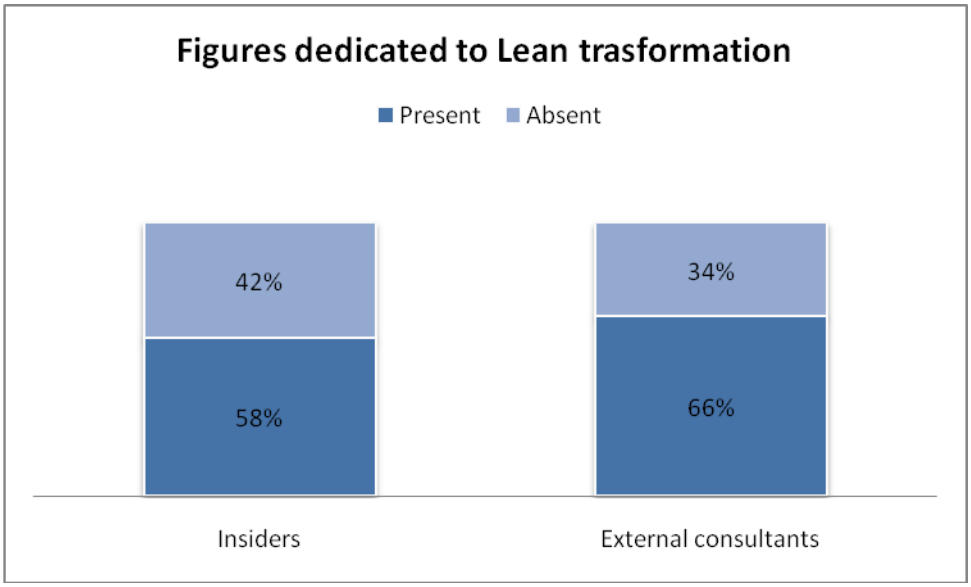


'Soft Lean'

Going beyond lean practices per se, an interesting point of view is the 'soft' part of lean implementation, that means looking at the human resource part of it. To resume a quote already mentioned in the second chapter, "soft practices concern people and relations, while hard practices refer to LM technical and analytical tools" (Bortolotti, et al., 2014)

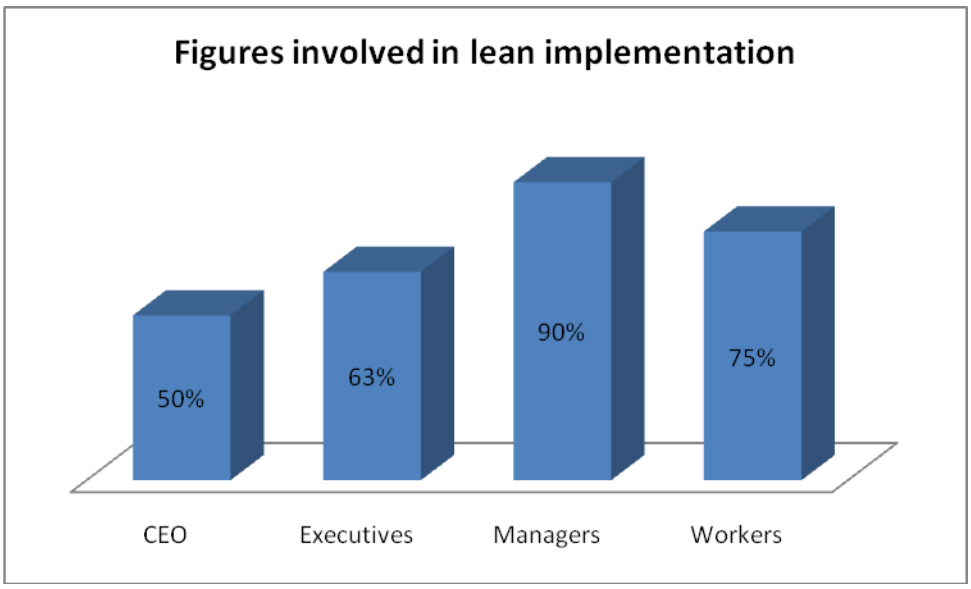
Two separate questions aimed at investigate which kind of people companies dedicate to lean implementation, in particular to understand whether these figures are internal or external to the organization. Questions 19 and 20 were formulated in the following way: 19) there are figures internal to your firm explicitly dedicated to lean techniques implementation 20) do you refer also to external consultants for lean techniques implementation? Respondents simply had to tick the *Yes* or *No* box. The scenario that emerges is that the majority relies on dedicated figures to pursue lean implementation. 58% of the companies relies on internal figures to do it, and 66% engages external consultants. By cross-referencing we can see that actually 44% recurs to both internal and external figures to pursue lean transformation.

Figure 31: figures dedicated to lean transformation [n^{l}=114]



A question that followed aimed at recognize which figures mainly participate in the lean transformation process. Specifically, the term used was 'actively participate', to make sure of a real contribution of these figures. Usually, managers are the most involved in the lean transition, being *active* in the 90% of cases. The second kind of figure more active in the transformation is the one of worker (75%). Following, we find executives (63%) and CEO, directly involved in only 50% of the companies. The importance of the involvement of these figures can be understood through a comparison with Top lean companies, that will be done in the next pages.

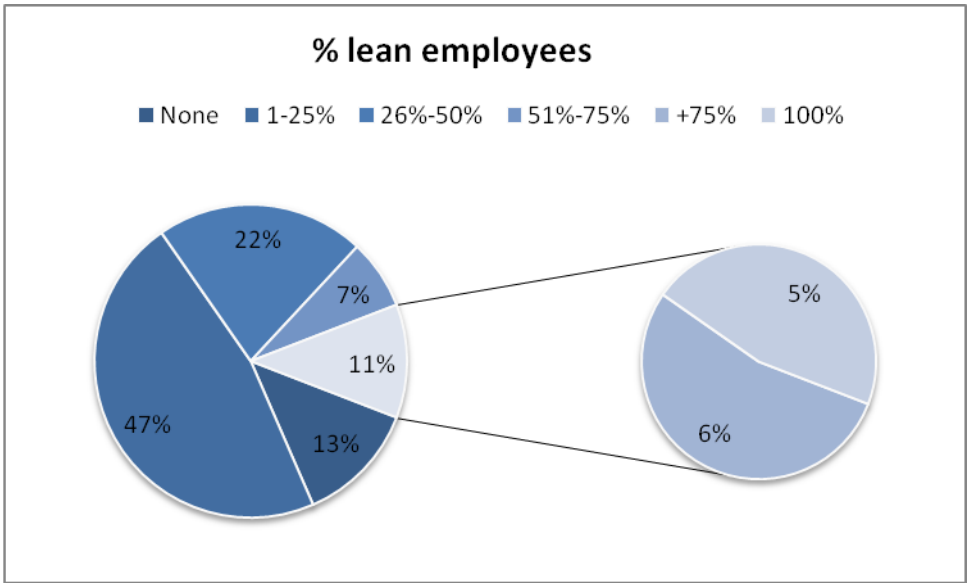
Figure 32: figures involved in lean implementation [n^{l}=114]



Another question aimed at understanding to which degree each company could be defined 'lean', and the degree of engagement was measured through the percentage of employees actually involved in lean projects or training courses. Actually, almost the majority of

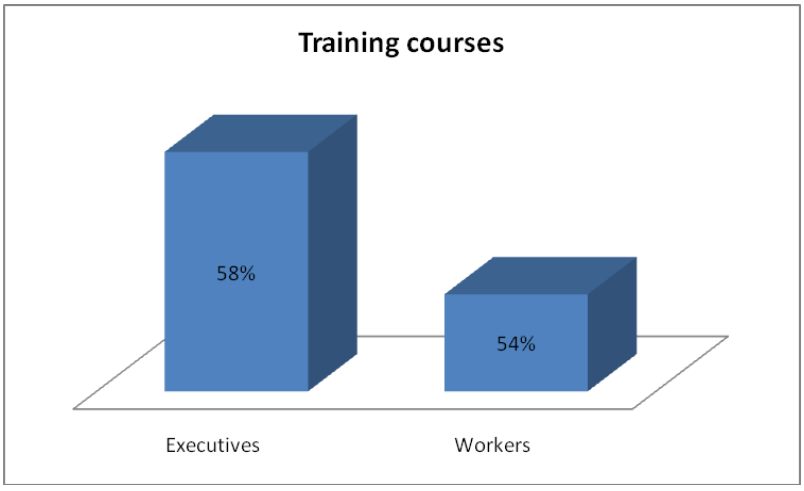
companies (47%) employed only up to 25% of the employees in this kind of projects. The following 22% of companies employ between 26% and 50% of employees, and another 7% between 51% and 75%. The upper 11% employ instead more than 75% of employees in lean projects, and of those a 5% can be defined *purely lean* with all the employees (100%) involved in lean.

Figure 33: percentage of lean employees [n'=114]



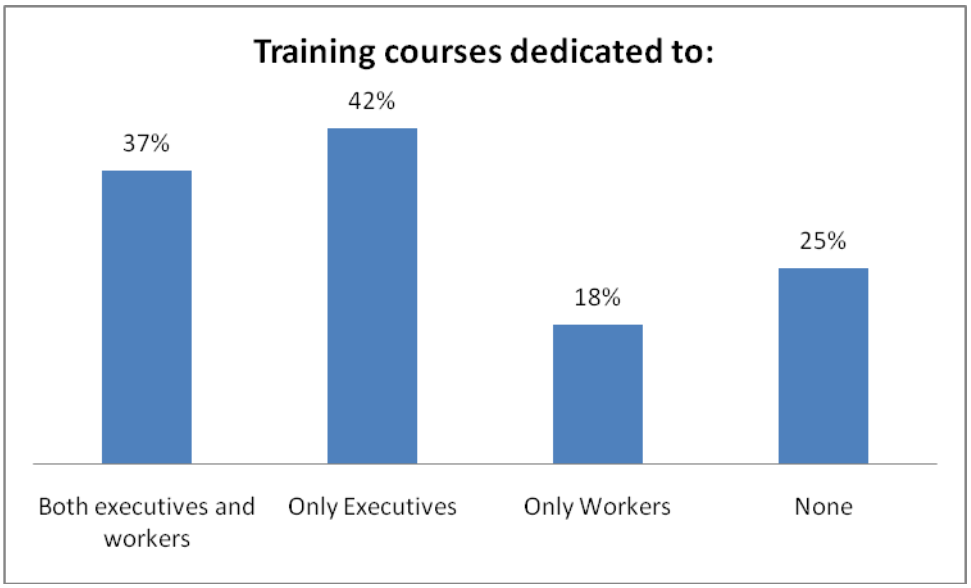
In the previous question, to classify an employee as involved in a lean project, it was required for him to be involved in a kaizen workstation or in a training course. Moving the focus on training courses, we wanted to investigate to whom they are usually dedicated: the only distinction made in the survey was between generic workers (on the shop floor) and executives (here the term *executives* encompasses executives, managers, and employees). The difference between the two categories is not so marked, with only a 4% more courses dedicated to executives with respect to those dedicated to workers. The percentage is higher than 50% in both cases.

Figure 34: target of training courses [n'=114]



If we further breakdown the target of these training courses, the result is even more interesting: if it's true that 42% of companies dedicate training course only to executives, a good 37% invested instead in courses for both the categories; the smaller percentage (18%) dedicated them only to workers. A quarter finally didn't invest in training courses at all.

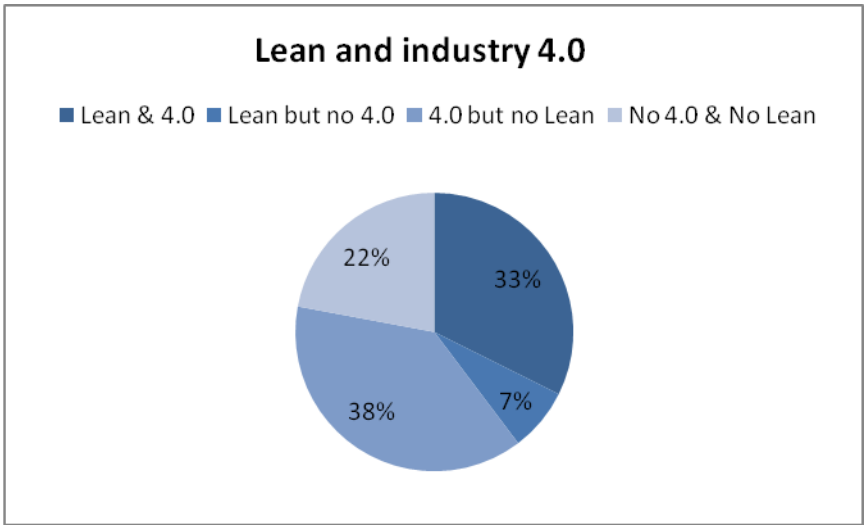
Figure 35: target of training courses (pt.2) [n^{l}=114]



Lean & Industry 4.0

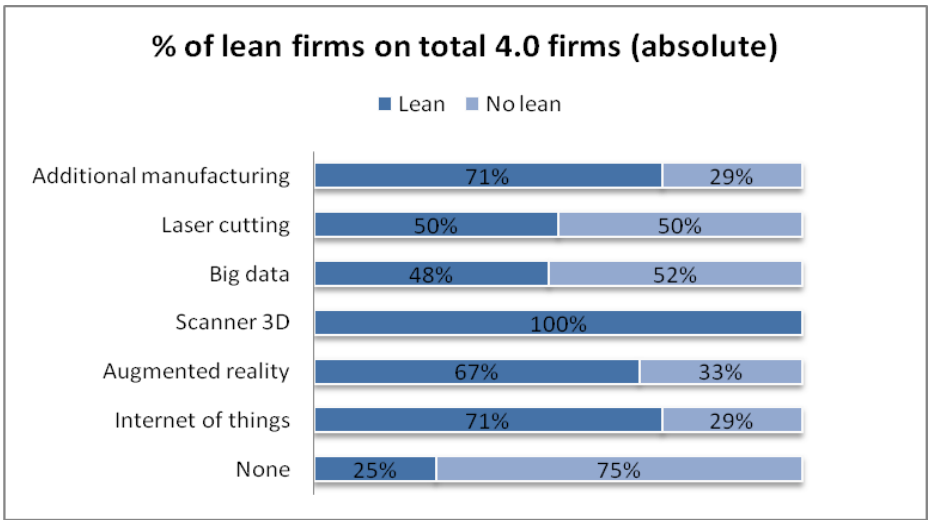
An interesting cross-reference of the data collected is between lean and industry 4.0. Dividing between companies that apply just one of the two, those who apply both, and those who don't do either of the two, we can observe the higher percentage –precisely 38% –is related to those that apply industry 4.0 but none of the lean techniques, followed by the 33% that apply both. It is quite rare, instead, to find companies applying lean techniques but none of the industry 4.0 (only 7%). Finally, 22% don't do either of those.

Figure 36: Lean and industry 4.0[n^{l}=114; n^{i} =68]



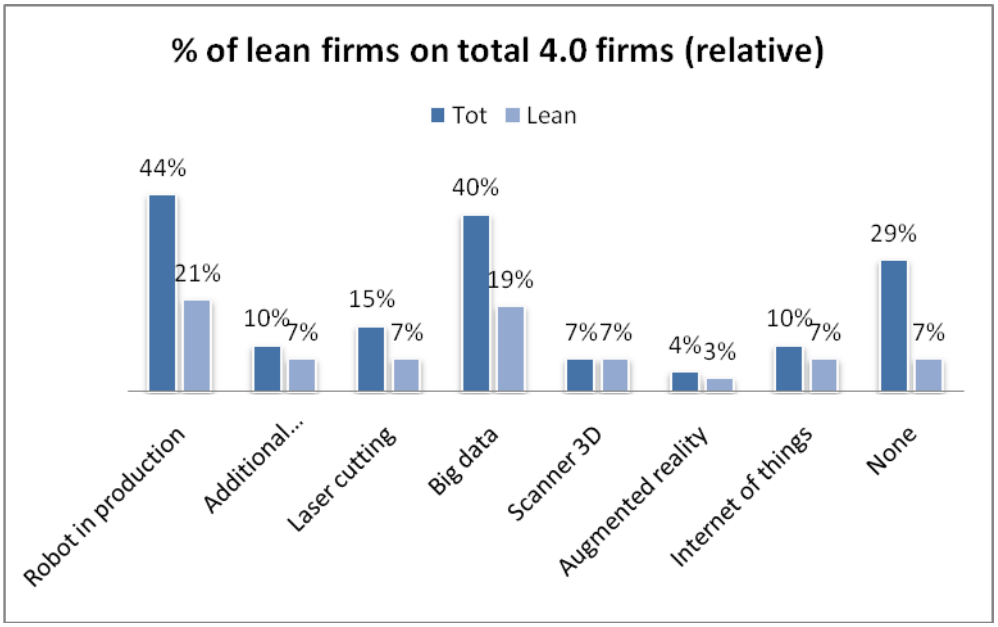
Another cross-reference conducted aimed at finding out which was the number of firms implementing lean for each of the industry 4.0 techniques. The results are represented here below (pay attention to cross-reference once again these results with those of figure *Industry 4.0 technologies*). The greater correlation is found for the scanner 3D technology: 100% of companies adopting this technology also implement lean; however, we have to remember that firms actually adopting 3D technology are only 7% of the sample. The other two most used by lean companies are additional manufacturing and internet of things, with a 71% of firms implementing it being lean; both these technologies, however, accounted for a 10% of the sample. This means that also if the percentage of implementation is high, the absolute number of firms is still low[16], representing only an absolute 7%. An additional graph (cf. figure 38) has been drawn to show the percentages relative to the whole sample, so more –and more accurate –comparisons can be done.

Figure 37: percentage of lean firms[n^l=114; n^i=68]



[16] More data about the topic would be necessary to give higher significance to these results.

Figure 38: percentage of lean firms (pt.2) [n^{l}=114; n^{i} =68]



3.3. TOP & WORST FIRMS

A further breakdown of the sample was made, identifying the best (here called *Top*) and the worst firms, in the hope of finding out some determinant factors that characterize these two set of enterprises.

3.3.1 TOP & TOP LEAN

The parameters used to identify the Top firms are the following:

- $CAGR^{17}_{(2014\text{-}2016)} > 7\%$
- $EBITDA/Sales_{(2014\text{-}2016)} > 10\%$
- $Debt\ ratio^{18}_{(2014\text{-}2016)} < 80\%$

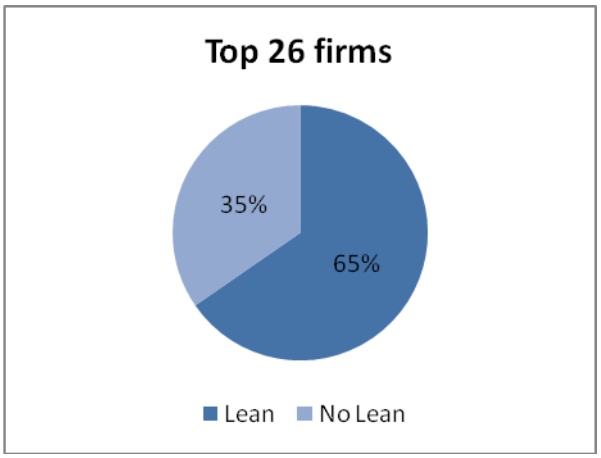
The number of firms that meet these three criteria are 26 out of 248, representing the Top 10%. In particular, out of the 26 Top firms, 17 implement lean, representing a 65% of the Top.

From now on, we will take forward the join analysis of *Top* and *Top lean* companies –with this last term referring to all that firms that both implement lean techniques and belong to this top 10%. The analysis will be conducted simultaneously to better make comparisons and to understand whether lean implementation is a critical success factor.

[17] CAGR is calculated on revenues

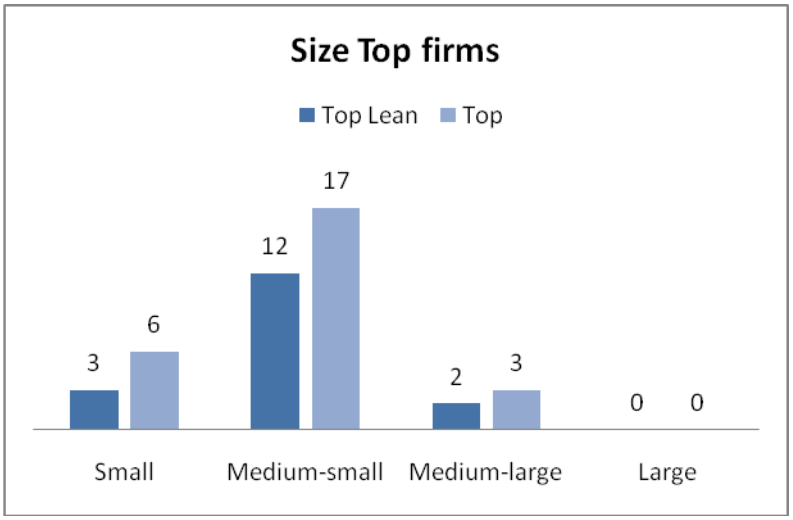
[18] Debt ratio is calculated as $1 - \frac{1}{mean(leverage\ ratio\ (2014-2016)}$.

Figure 39: Top 26 firms[n^{l}=114; n^{t} =26][19]



Starting from a quick look to the basic characteristics, namely size and age, we can observe that none of the large companies belong to the top 10%. The majority (65% of the Top companies and 71% of the Top lean) are within the medium-small category, followed by small size ones, and medium-large, with definitely lower percentage.

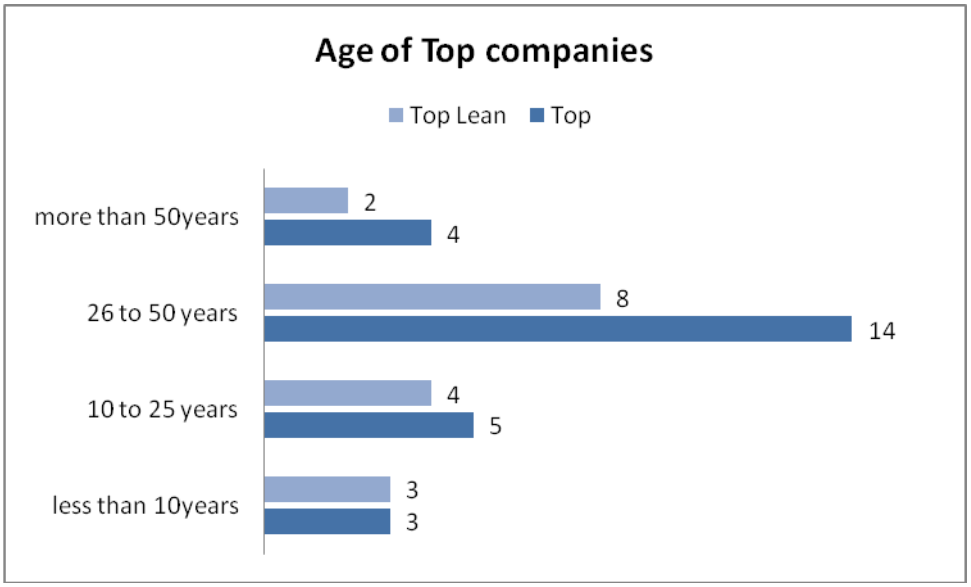
Figure 40: Size of Top firms [n^{t}=26; n^{tl} =17][20]



The second basic parameter we just mentioned was companies' age. Around 30% of the Top have less than 25 years, of which 3 even less than 10 years. Of these 8 *young* companies, 7 are lean, this implying that lean implementation can be a critical success factor, especially for young companies to reach a good financial performance already in the short run. The majority of top firms has between 26 and 50 years, and a 57% of those are lean. Just 4 companies, meaning a 15% of the 26 Top firms, have instead more than 50 years, and of those half are lean.

[19] n^{t} is referred to the sample size of Top firms
[20] n^{tl} is referred to the sample size of Top Lean firms

Figure 41: Age of Top companies [n^{l}=26; n^{il} =17]

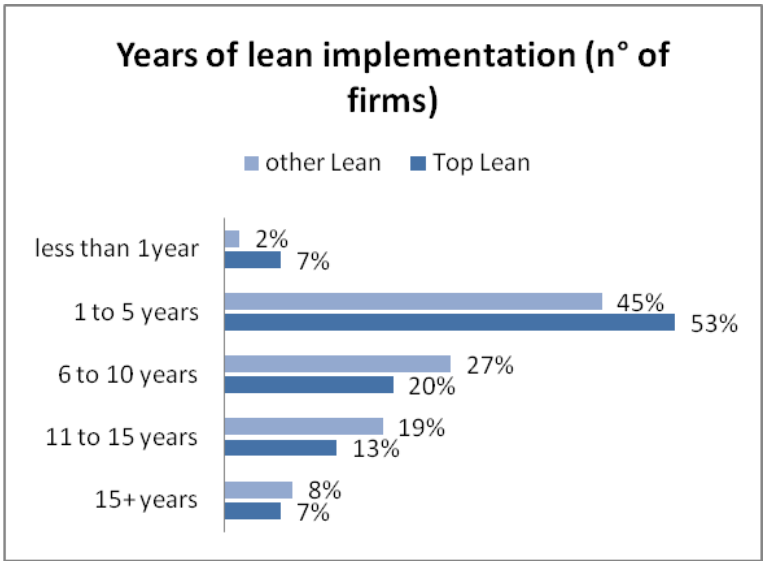


With regards to 'seniority' an interesting thing to do is to look at the years of implementation of lean practices among the Top lean. By comparing the top lean with the 'other lean' (meaning the rest of lean companies in the sample, that are not among the Top) we could deduce that the number of years of implementation –in other world since how many years lean practiced are implemented –is not so significant for performance results. However, this is not a statement that can be done just looking at one graph, and more analysis should be conducted.

Table 4: years of lean implementation

N° of years	Top Lean	Other Lean
No answer	2	2
15+ years	1	9
11 to 15 years	2	21
6 to 10 years	3	30
1 to 5 years	8	50
less than 1year	1	2

Figure 42: years of lean implementation[n^{l}=114; n^{il} =17]

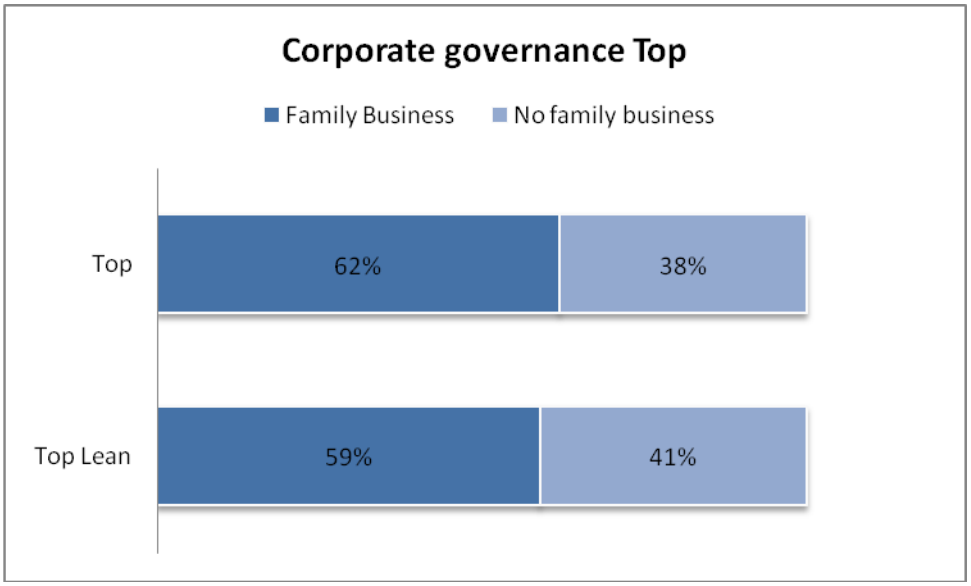


We indicated both the percentage and the number of firms because only looking at the percentage –for so small numbers –can be misleading. For example, we can immediately see that 7% of Top lean companies implement this kind of practices since less than one year, but 7% in this case correspond to just 1 company over the 17 Top lean. This is the reason why the

two figures must be read together. Anyway, most firms –both Top lean (53%) and other lean (45%) – implement lean since 1 to 5 years. The following 27% of other lean companies, instead, implement lean since 6-to-10 years.

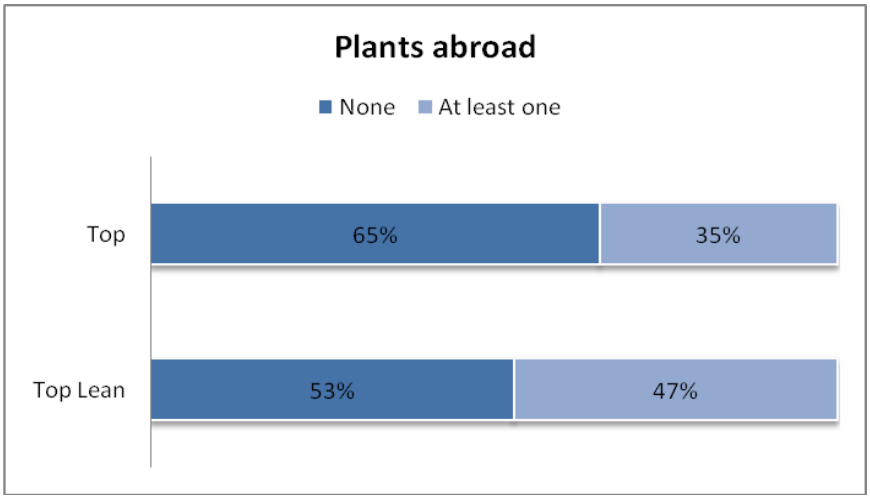
With regards to corporate governance, namely whether companies are family businesses or not, the difference between Top and Top lean is barely visible, and the fact that the majority are, in both cases, family businesses, perfectly mirror the sample.

Figure 43: Corporate governance of Top companies [n^t=26; n^{tl} =17]



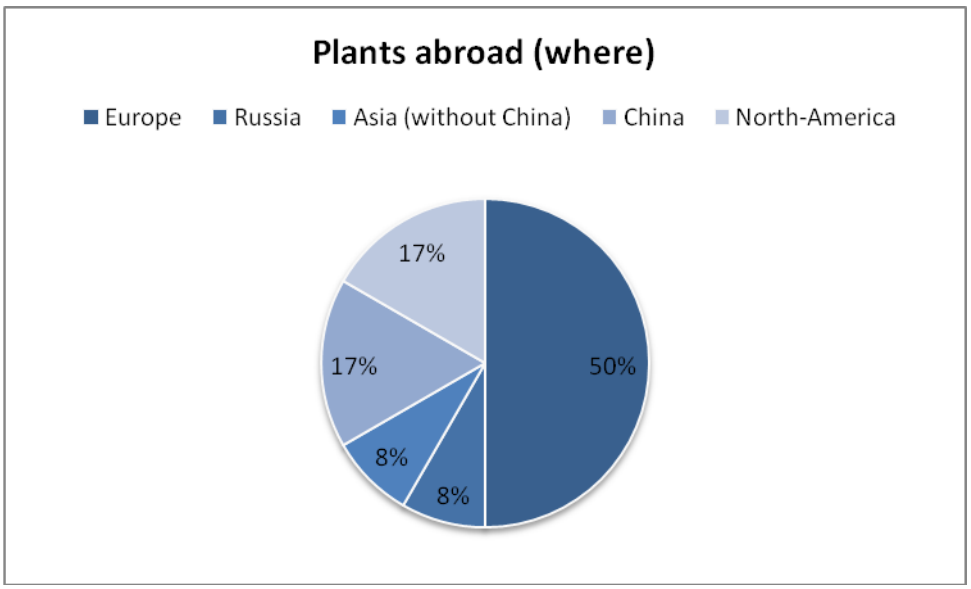
Shifting the focus to production, the difference between Top and Top lean is, instead, more marked. In particular with regards to the presence of production facilities abroad, Top lean are more present abroad with respect to Top firms. Precisely, 65% of the Top companies don't have any manufacturing facility abroad, whereas this percentage diminish to 53% for Top lean; we can therefore state that to reach good performance is not necessary to move production abroad, and that, in any case, lean companies tend to relocate production abroad more than non-lean ones.

Figure 44: Plants abroad [n^t=26; n^{tl} =17]



If we want to look at where these facilities are, the 50% is situated in Europe (58% if Russia is considered), and the following 25% in Asia, if China is included; the rest is in North America.

Figure 45: Plants abroad (location) [n^t=26]



Even more interesting than where manufacturing facilities are, is to look at their main market. Both for Top and Top lean companies, the main market is the Italian one, with a higher percentage for Top lean, i.e. 59% versus the 50% of Top companies. In second place we find Europe (of course, Italy not included), which represent the main market for 24% of Top lean, and 35% of Top companies; we could say, the 9% less in the Italian market of Top companies is recouped in the European, where they outweigh Top lean of 11%. For North America and Oceania, the percentage are way lower and extremely balanced among the two categories.

Figure 46: Main market of Top companies [n^t=26; n^{tl} =17]

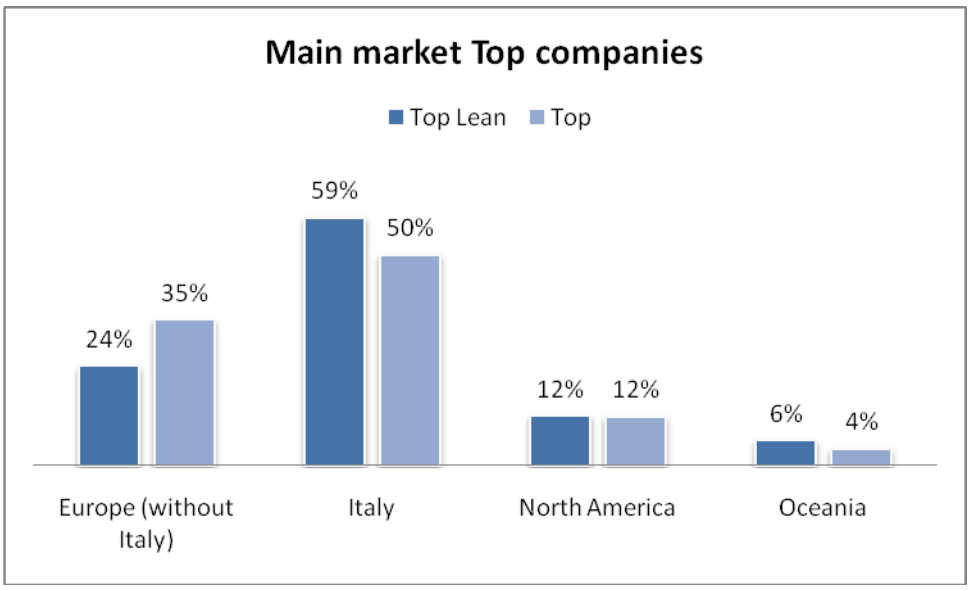
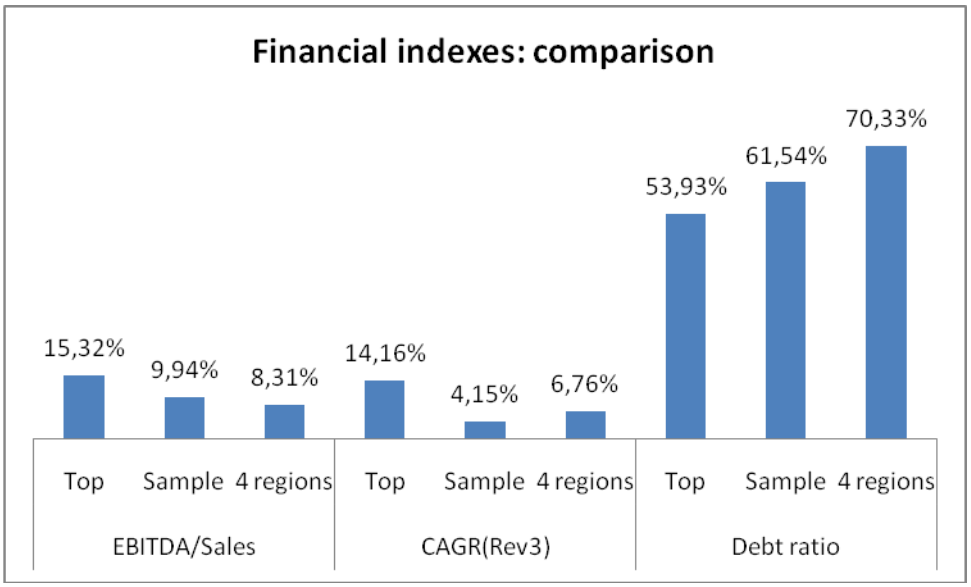
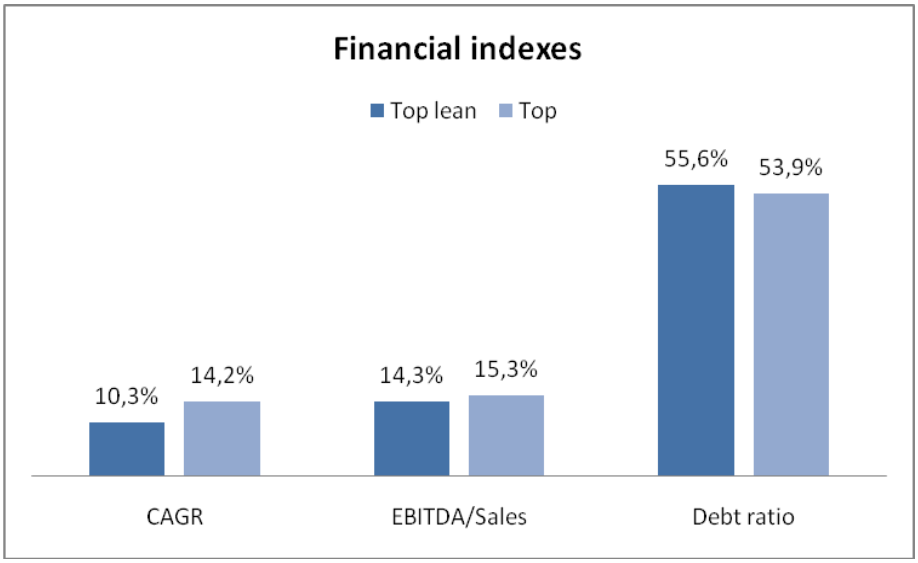


Figure 47: comparison of financial indexes[n^t=26; n^s =248; n^x=16021]



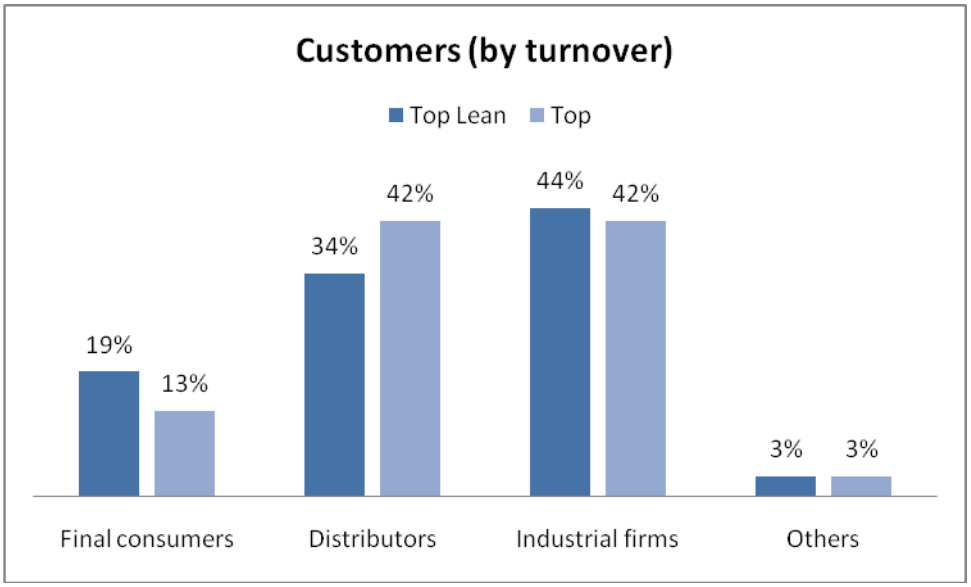
With regards to financial indexes, a first comparison was made among Top firms, the sample, and the 4regions. Obviously, the mean of Top firms is way higher (or lower –for the debt ratio) for all three indicators. Even more interesting, is comparing the financial indexes of Top and Top lean companies. Surprisingly, all three indexes are better for Top companies with respect to Top lean. The difference for EBITDA/Sales is not so marked, only one percentage point, but slightly more marked the debt ratio, up to 1.7%, and even more for CAGR on revenues –almost 4% difference–. These results are not so nice for lean advocates, but before making any statement about lean techniques, the combined effects of several factors have to be considered. A possible explanation of this result is that, as we saw above, the majority of firms belonging to the Top lean group implement lean since 5 years or less; this imply that benefits deriving from lean practices may not be visible yet.

Figure 48: comparison of financial indexes (pt.2) [n^t=26; n^{tl} =17]



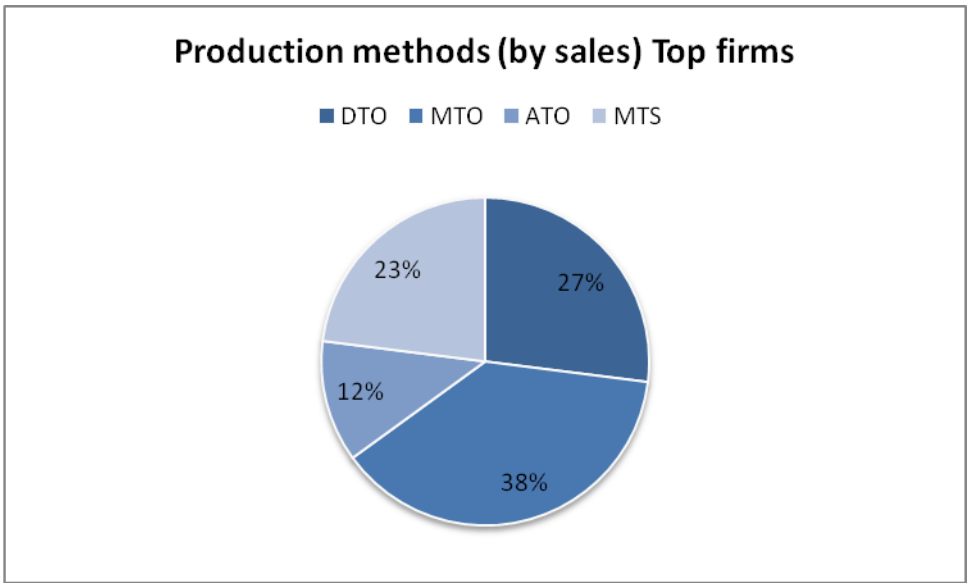
Looking at which kind of customers enterprises address their product to, is not really explanatory. Maybe, now knowing that financial performance is higher for Top companies, we could say that focusing less on final consumers and more on distributors is a strategy that pays back more, due to the fact that the higher percentage of the turnover for Top firms comes from distributor; for what concerns industrial firms the percentages are more or less the same.

Figure 49: type of customers by turnover [n^t=26; n^{tl} =17]



Also looking at which production methods Top firms use does not tell us a lot about the determinants of success. The percentage of implementation of the four methods (Design To Order, Manufacture To Order, Assembly To Order, and Make To Stock) are really similar, both for Top and Top lean companies, and for Top companies and the rest of the sample (to recall, for the sample values were: 30% DTO, 33% MTO, 15% ATO, 22% MTS).

Figure 50: production method by sales – Top firms [n^t=26]



Way more interesting is the analysis of which kind of production layout is implemented by the top 10%. The following two pictures will illustrate to which degree the various layout are carried out, respectively for Top and Top lean companies. Two distinct pictures were kept because in this case percentages are quite different. What does not change is that none of the two groups apply fixed position layout, that was however applied in just the 2% of cases in the sample. Cell layout is another type of layout that remain quite stable –around a 10% (±2%) –for the three different categories. Functional layout, instead, is implemented in the 36% of cases by Top firms, exactly the same percentage of the sample, but the portion of firms implementing it goes up to 47% for Top lean. By contrast, line layout, that was applied by 37% of firms of the sample, increase a little for Top lean (41%), but goes up to 56% for Top companies, creating an 11% difference between these last two categories.

Figure 51: Production layout of Top firms [n^t=26]

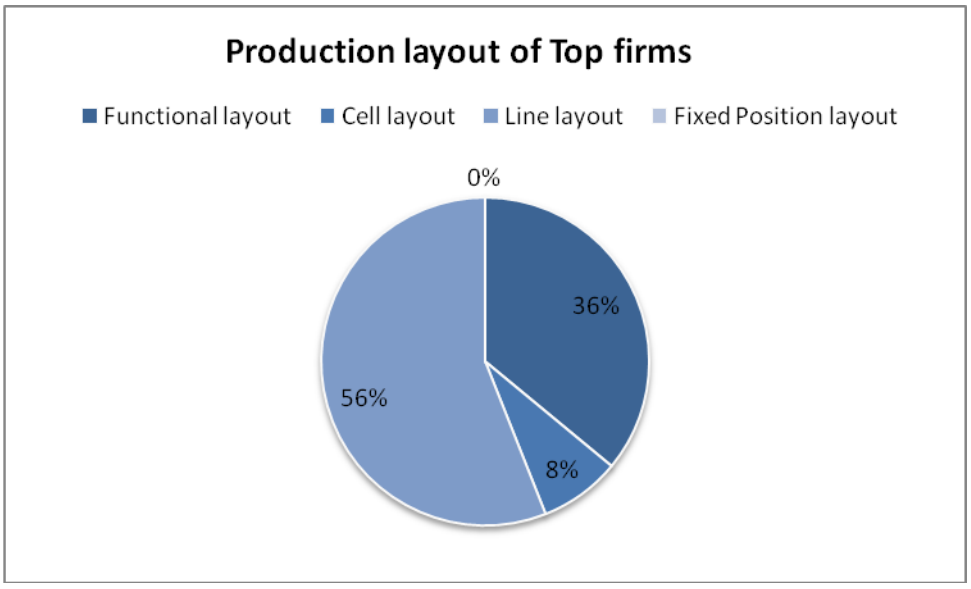
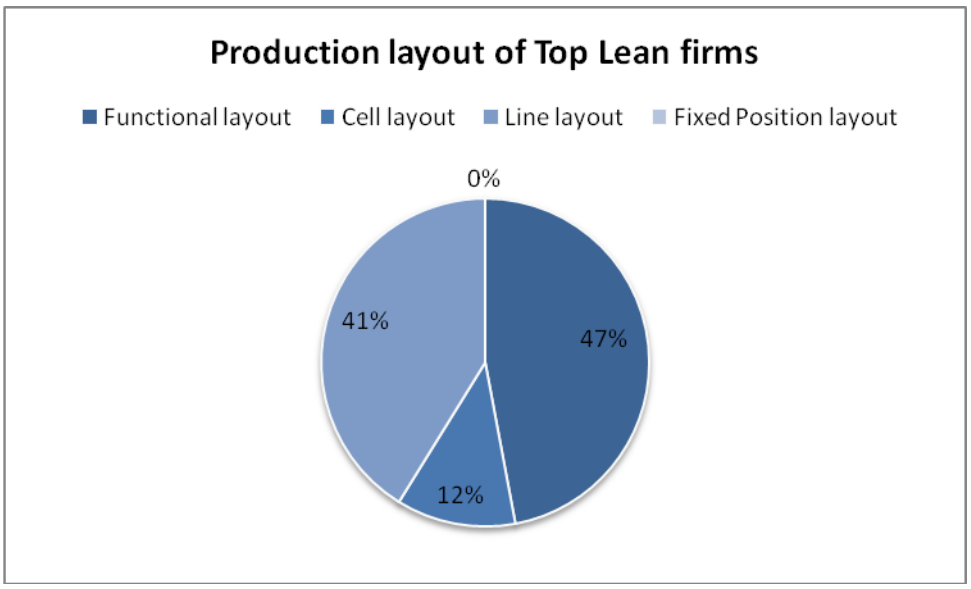
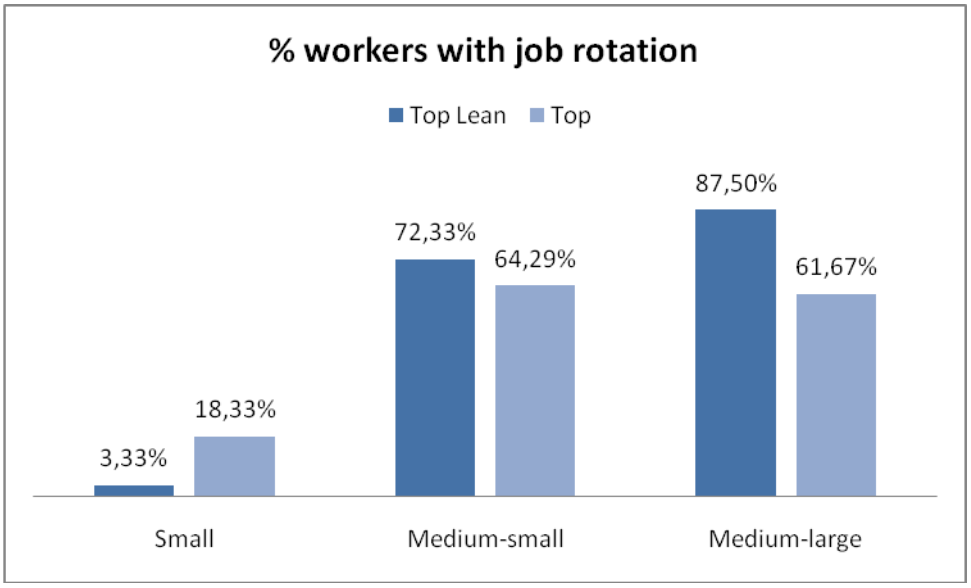


Figure 52: Production layout of Top Lean firms [n^{tl} =17]



Another interesting characteristic to focus on, is the percentage of workers able to work in more than one workstation, and results in this case support the literature[21]. Unfortunately, for small size companies results are biased by the low number of firms in the sample, in fact, the percentage is so low because two of the three firms under question do not have workers with job rotations at all, and the remaining firm have only a 10%. For medium-large companies instead the gap between lean and Top lean is due to the 10% workers with job rotation in the non-lean firms, very low compared to the 85% and 90% of the two medium-large top lean. As we can see, however, Top lean firms have a substantial higher portion of multi-skilled employees.

Figure 53: percentage of workers with job rotation [n^{t}=26; n^{tl}=17]



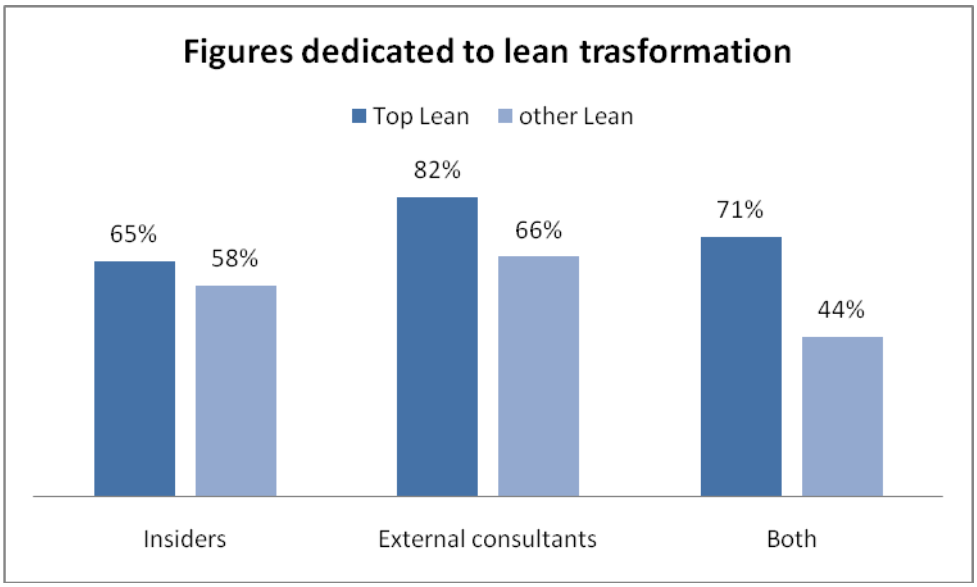
Before shifting to the analysis of the *Worst*, some comparisons between *Top lean* and *other lean* companies will be made, always with the aim of identifying which are the critical success factors in lean implementation.

Soft lean

Starting this time with the analysis of *soft lean*, a first difference between Top lean and other lean companies can be found in the degree in which they involve figures explicitly dedicated to lean implementation. The gap is not too deep (7%) with regards to internal figures, but it is deeper for the involvement of external consultants –Top lean engage external consultants 16% more often –and even more deep if we consider how many firms actually engage both this figures simultaneously (+27%).

[21] Job rotation and multi-skills is one of the cornerstone of Lean manufacturing.

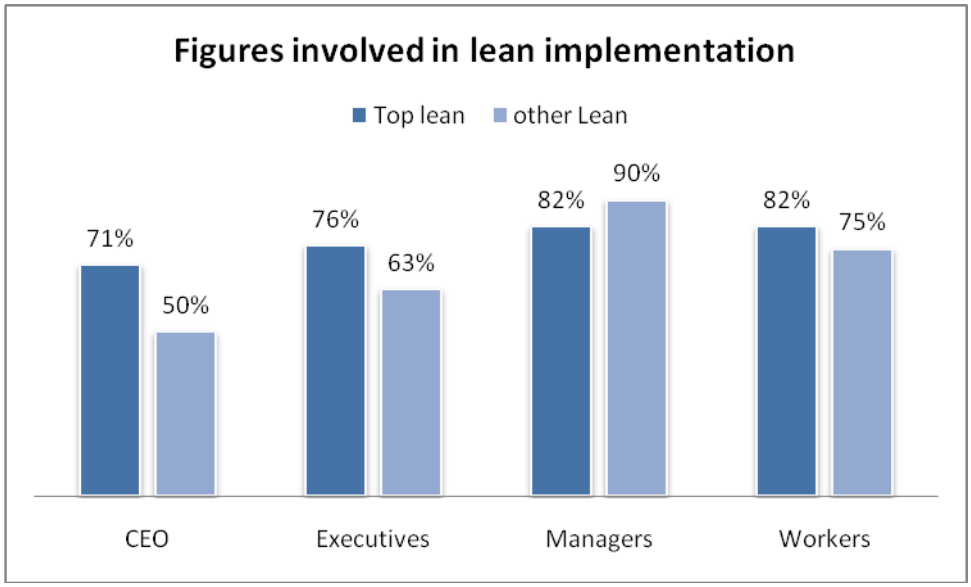
Figure 54: Figures dedicated to lean transformation [n^{l}=114; n^{tl} =17]



We can therefore deduce that the involvement of people explicitly dedicated to lean implementation can be a success factor, and that it is more effective if people involved are both internal and external.

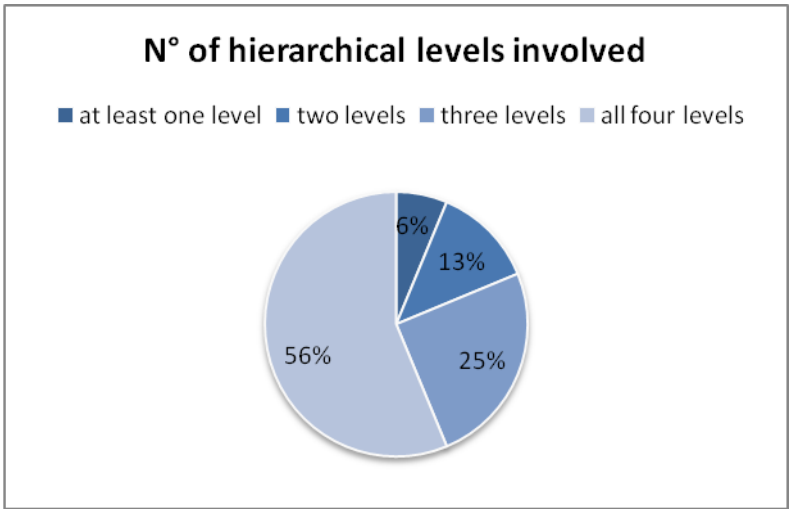
Deepening the analysis to see which internal figures are usually involved, we immediately understand where is the real difference between Top lean and other lean: the gap between the two grows by moving up the hierarchy. More specifically, percentages are more similar (just 7% difference) at the lower levels of the hierarchy, namely for workers and managers (for which other lean companies are even better than Top lean), whereas the gap starts opening moving to executives (+13% for Top lean) and it increase even more when considering the involvement of the CEO (+21%).

Figure 55: figures involved in lean implementation [n^{l}=114; n^{tl} =17]



Another really interesting result is the following: the number of different hierarchical levels (actively) involved in lean implementation was calculated for Top lean companies. Just in one case none of the above mentioned figures were involved, but external consultants were engaged. In all the other companies at least one of these hierarchical levels was involved in the lean implementation, and, even more interesting, the number of companies is duplicating with the increase of the number of hierarchical levels involved. Specifically, for 6% of firms the number of levels involved in lean implementation in only one, it becomes 13% for two levels, almost double to 25% for three hierarchical levels, and more than double up to 56% for the four levels (CEO, Executives, Managers and Workers all involved).

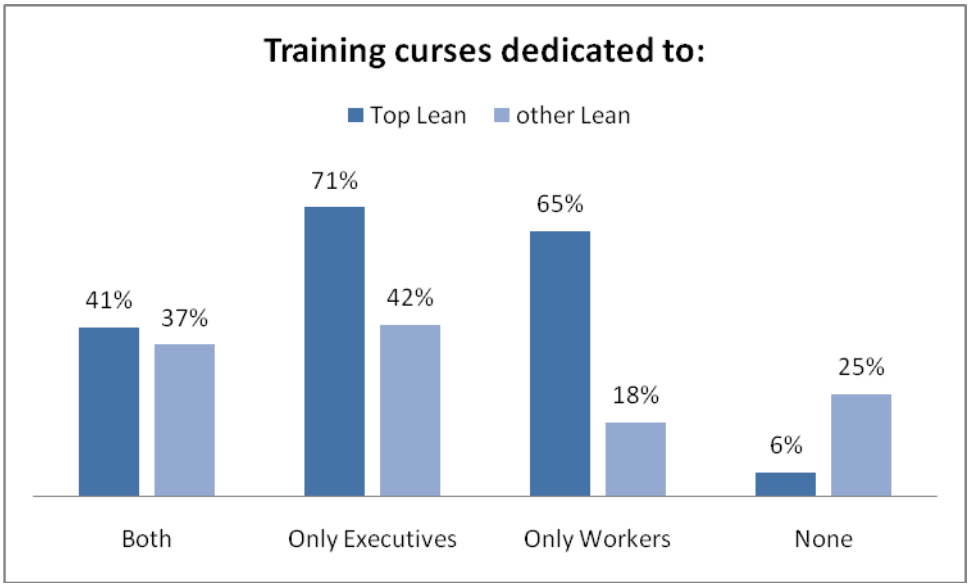
Figure 56: number of hierarchical levels involved in lean implementation [n^{tl}=17]



Other substantial differences between Top lean and other lean can be noticed in the target of training courses. If the portion of companies addressing training courses to both executives and workers is more or less the same, it is way lower the proportion of firms dedicating them to just one of the two categories of employees –specifically 71% vs. 42% of cases in which training courses are dedicated to executives only, for top lean and other top respectively, and 65% vs. 18% (with a 47% difference) for those dedicated to workers only.

In line with the trend, the percentage of other lean is higher for those not doing training courses at all –with the 25% not doing courses at all versus the 6% of Top lean –. Thus, the overall scenario tells us that Top lean companies invest way more often for training courses with respect to other lean, with the latter tending to dedicate them to both workers and executives once they decide to invest.

Figure 57: target of training courses[n^{I}=114; n^{II} =17]

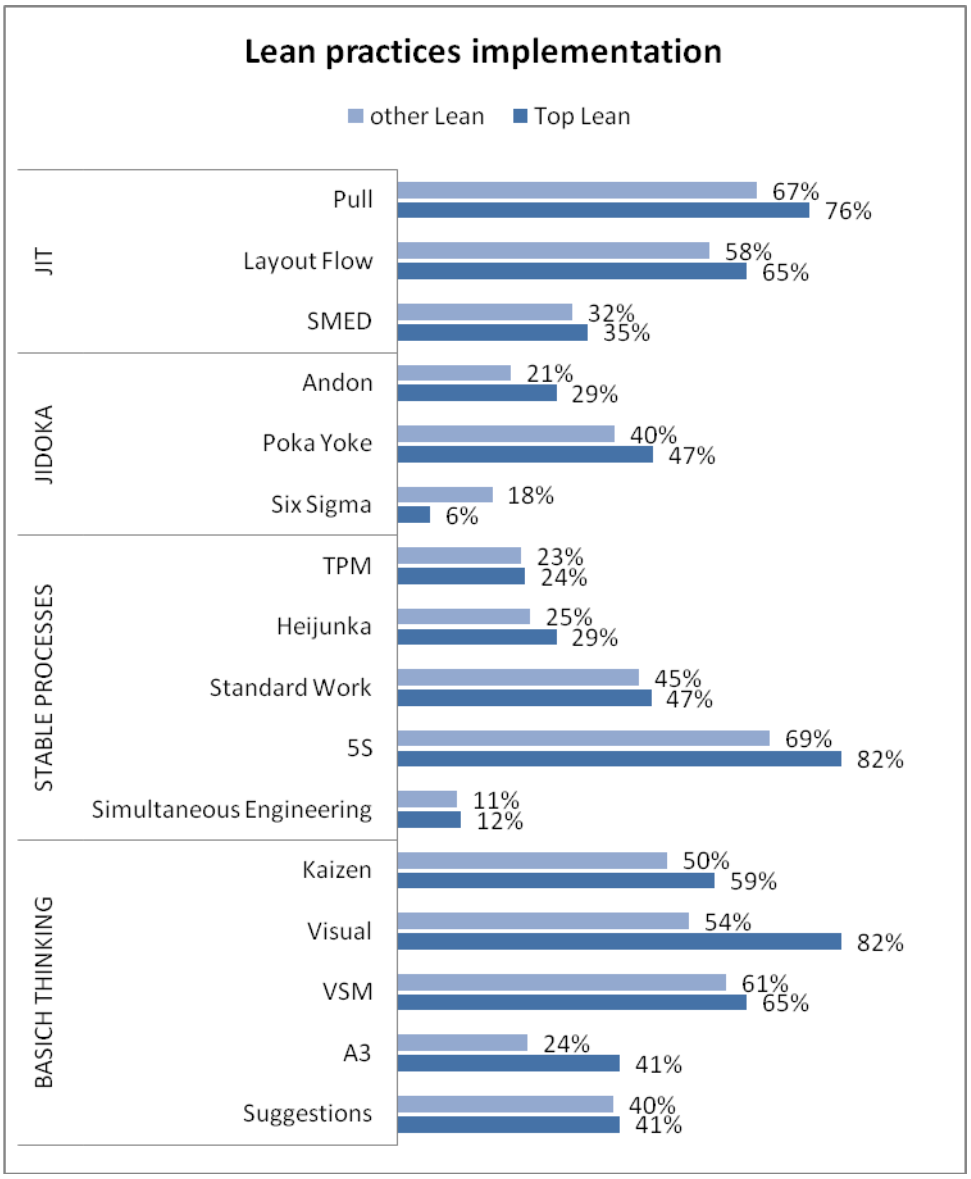


The overall picture that emerges from the quick analysis of these elements, i.e. the figures explicitly dedicated to lean implementation and the target of training courses, tell us something about the importance of the human resource side of lean, namely *soft lean*, for the achievement of better results. Further research should deepen these aspects.

Lean practices

Of course speaking about soft lean without investigating the 'hard' side of it makes no sense. If it s true that the soft part is important, it is still not enough to explain a company's success alone. A comparison of Top lean and other lean, with regards to which practices they implement and in which organizational areas, is reported in figure 58.

Figure 58: lean practices implementation [n^{l}=114; n^{tl} =17]

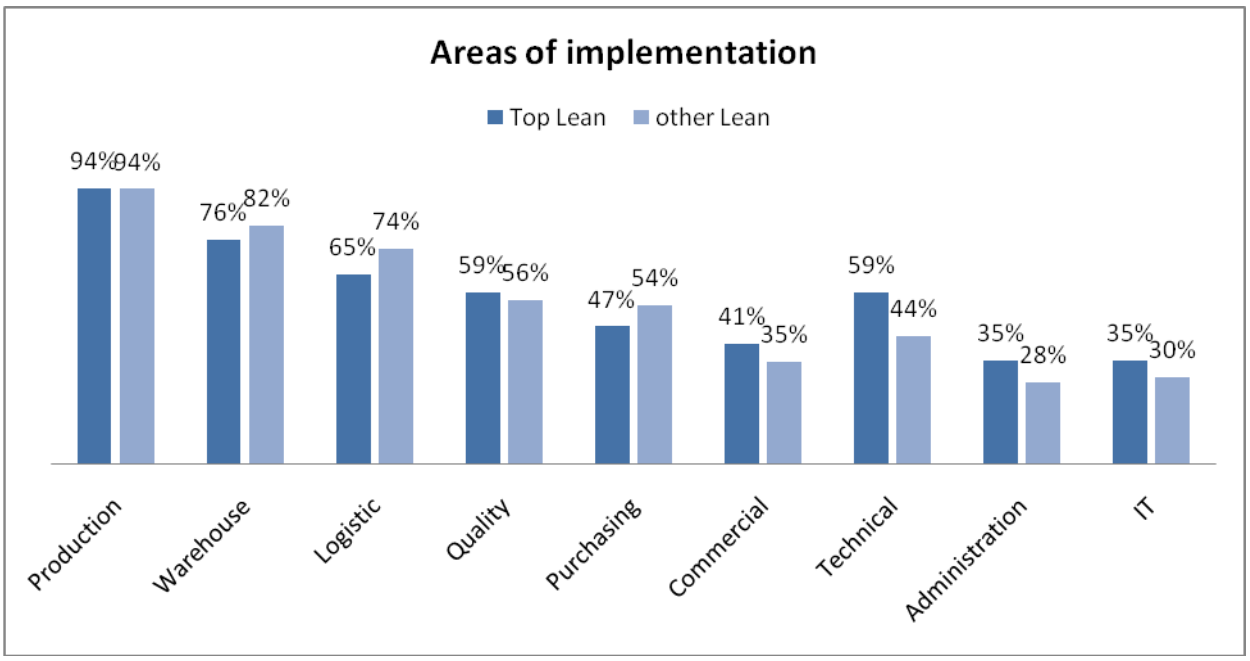


From a quick glance at the above graph, what immediately emerges is that Top lean firms as a whole tend to implement more lean. In fact, with the exception of Six sigma, that is way less implemented by Top lean firms with respect to other lean (6% vs. 18%, respectively), the percentage of implementation are higher –for Top lean companies –for each practice. Defining 'relatively small' gaps whenever the deviation is within a +10% for Top lean companies, the most significant discrepancies in the application of a practice can be observed for 5S, Visual, and A3. The higher is for visual management, implemented by 82% of Top lean firms, and just by 54% of other lean (Δ28%); A3 is instead implemented by 41% of Top lean versus 24% of other lean (Δ17%); 5S, finally, have just a 13% discrepancy, but the percentage of implementation are way higher than for A3 (82% vs. 69%). Furthermore, if we look at the most used practices form Top lean perspective, 5S and Visual are the most popular, with 82% companies implementing them. Right after these two practices, the most

diffused is Pull, with 76%, that turns out to be the second most used for other lean companies, after 5S. In fourth place we find Layout flow and value stream mapping (VSM), both with 65% (and 58% and 61%, respectively, for other lean). Kaizen, finally, is the last practice that exceeds the 50% threshold of percentage of application, with 59% in Top lean companies and 50% in other lean. All the other practices are implemented by less than half of the firms, with values ranging from 47% to 6%, and with Six sigma and Simultaneous engineering turning out to be the least implemented.

Looking then at which are the organizational areas in which lean is mostly applied[22], the unquestioned winner is production, with 94% of firms implementing lean there, both for Top lean and other lean.

Figure 59: areas of lean implementation [n^{l}=114; n^{ol} =17]



The top three areas are production, warehouse (76% Top lean vs. 82% other lean), and logistic (74% vs. 65%), jointly considered as 'extended production'. However, both for warehouse and logistic, the percentages are higher for other lean with respect to Top lean (with a 6-9% gap). Another area in which other lean apply more techniques than Top lean is purchasing; in all the other areas the other way round is valid. If we consider again a +10% as 'relatively small' gap, the only area in which there is a substantial difference between the two categories of firms is the technical office, in which of other lean just the 44% implement lean, whereas of Top lean the 59% does.

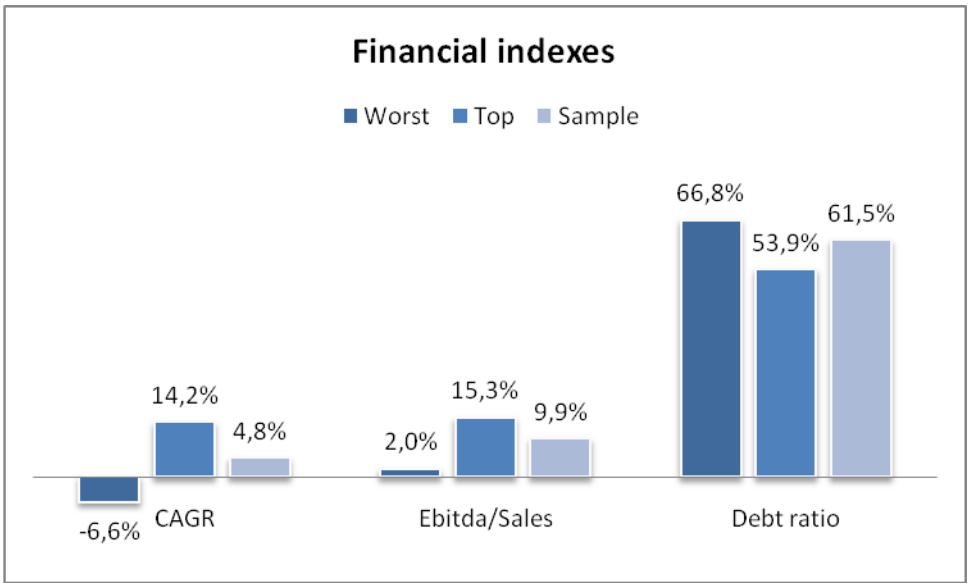
[22] To draw this graph, we consider lean as 'implemented' in an area if at least one of the lean practices mentioned in the previous graph are implemented there.

3.3.2 WORST & WORST LEAN

In addition to the analysis of the top firms, we considered appropriate to insert also that on the 'Worst'. Parameters to identify 'the worst' have been however slightly modified with respect to those used to identify the Top. The initial reasoning was about identifying the worst 10% according to the three indicators –CAGR on revenues, EBITDA/Sales, and Debt ratio –since the Top firms found following this criteria corresponded to the best 10% (being the Top 26 over 248). However, only one firm met the requirements. We therefore decided to consider just two over three indicators, namely CAGR on revenues and EBITDA/Sales, but still the number of firms meeting the requirements was only 6, too small to tell something about the characteristics Worst firms have in common. Thus, we decided to extend the constraint to the worst 20%. In this way, the number of firms meeting the requirement –i.e. having CAGR and EBITDA/Sales below the 20th percentile –raise to 19. It is not a large number, but it is still enough for identifying some general trends.

A first graph is provided to understand the average level of financial indexes.

Figure 60: comparison of financial indexes [n^w =19 ; n^t =26; n^x =248]

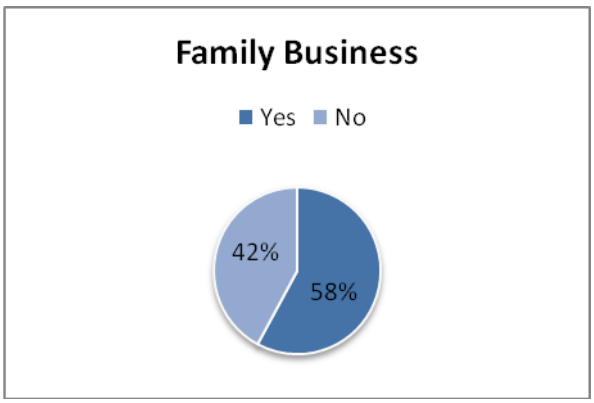


Clearly, the two indicators used to identify the worst 20th percentile are way lower than the rest of the sample (and of course of the Top), with CAGR on revenues being even largely negative (-6.6%) and EBITDA/Sales stopping at 2.0%. Unfortunately, the debt ratio is not so representative of worst firms, being 'just' 66.8%, 5% higher compared to the sample, but still lower, for example, than the average calculated for the 4regions (70.3%).

To get a glimpse of the basic characteristics of Worst firms we will quickly compare governance, size, and age of these companies with the ones of the sample.

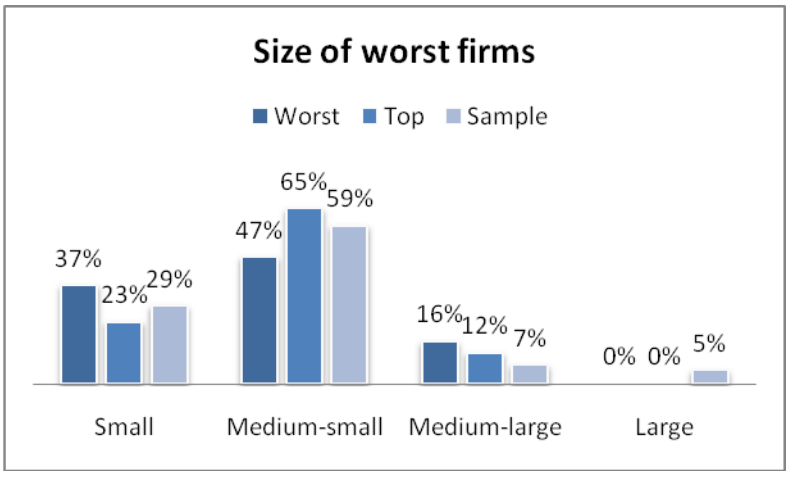
For what concerns the proportion of family businesses, the difference between the Worst and the sample is 7% (65% of the sample were family businesses), clearly not enough to correlate low performance to family business governance.

Figure 61: corporate governance Worst companies [n^w =19]



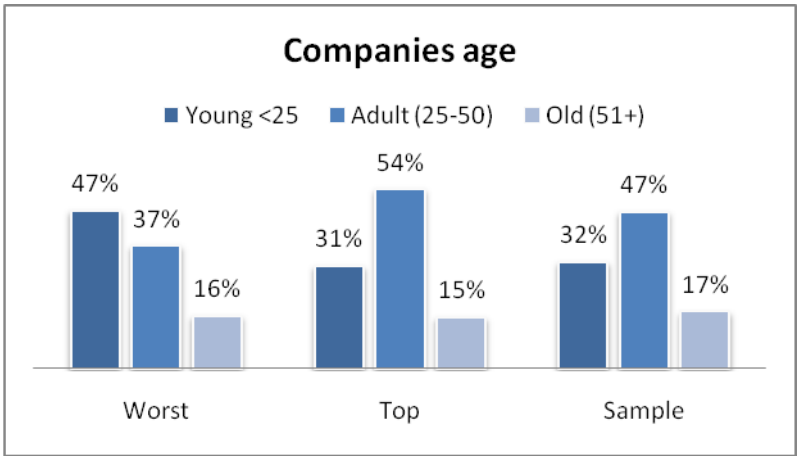
Looking then at the size of these firms, we can see that none of the large companies falls within this category; by contrast, the proportion of both medium-large and small companies in the Worst is higher than their proportion in the sample of about an 8-9%. The presence of medium-small companies, instead, is not so marked among the Worst.

Figure 62: Size of Worst companies [n^w =19 ; n^t =26; n^x =248]



Shifting to companies age, *Young* (to recall, meaning that ones with less than 25 years) tend to be more often within the Worst with respect to *Adult* (25 to 50 years old) and *Old* (more than 50 years old). More specifically, despite Young firms in the sample are the 32% of the total, and 31% for the Top, between the Worst almost half (47%) are Young. Conversely, Adult – that represent the majority of Top companies –are less than 40% among the Worst.

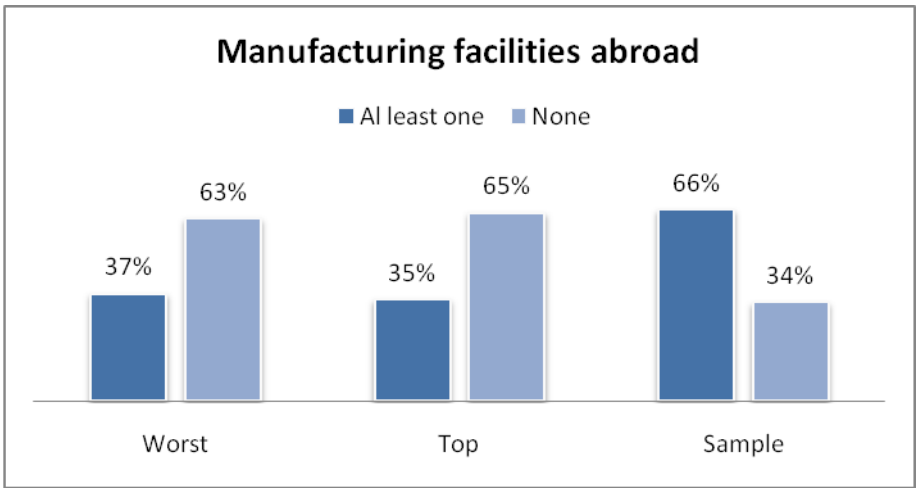
Figure 63: Companies age – a comparison [n^w =19 ; n^t =26; n^x =248]



For not being long-winded, from now on only the aspects on which the group of the worst 19 firms sufficiently differs from the rest of the sample, and most importantly from the Top, or are particularly interesting will be further analyzed.

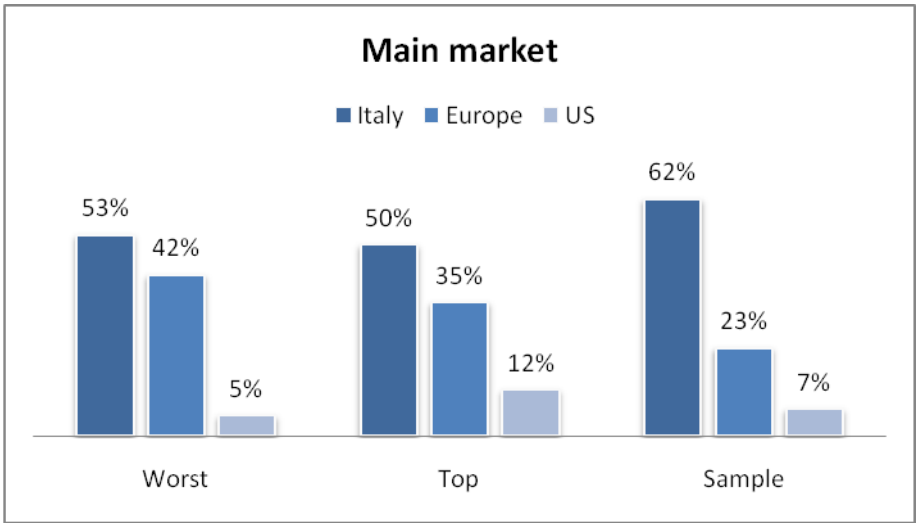
The first discrepancy found was about the presence of plants abroad. In particular, among the Worst, only the 37% have at least one, whereas among the sample the 66% does have. What is baffling, is that the percentage of firms with plants abroad is almost the same for Top and Worst firms, meaning that this factor does not affect financial performance, or better, is not a requisite nor for good nor for bad performance.

Figure 64: Plants abroad [n^w =19 ; n^t =26; n^x =248]



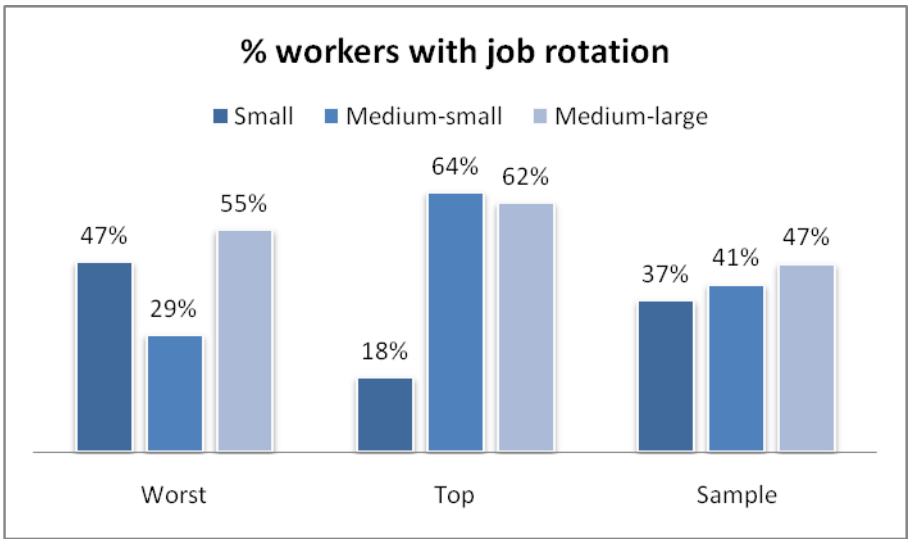
Analyzing the main market, once again we find the biggest difference between the sample and the Worst, but not between Top and Worst firms. With regards to the Italian market, the percentage is approximately the same, and grows a little bit for the European and North American market, but a ±7% difference is not enough to explain so large performance differences.

Figure 65: Main market – a comparison [n^w =19 ; n^t =26; n^x =248]



A significant difference between Top and Worst is found for the amount of workers with job rotation. As we saw in the previous section, the law percentage of medium-small Top companies is due to the small number of firms in the sample belonging to that category; anyway, the portion of employees able to work in more than one workstation is quite high for small size companies among the Worst. The downside is more visible for medium-small Worst companies, in which number of multi-skilled workers is half with respect to Top ones.

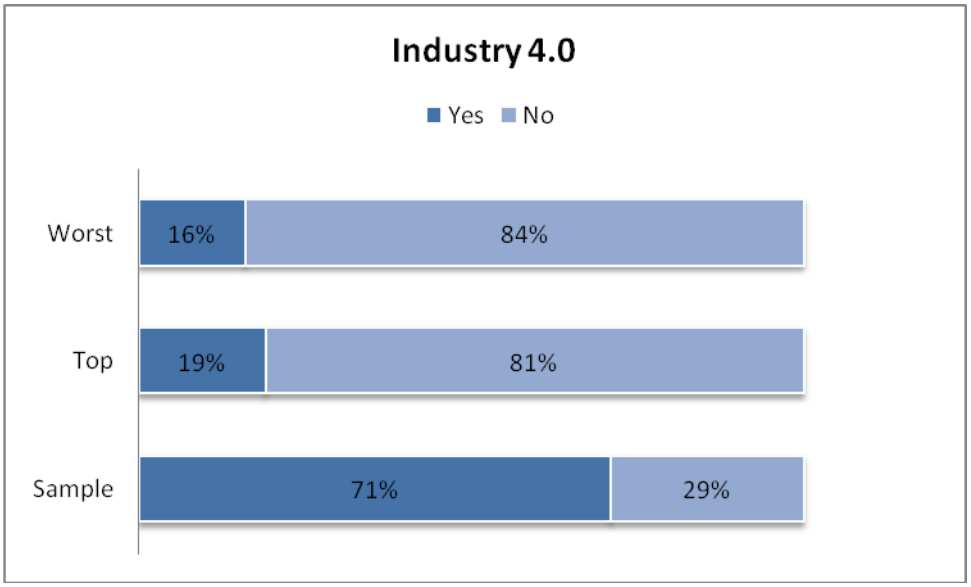
Figure 66: percentage of workers with job rotation – a comparison [n^w =19 ; n^t =26; n^x =248]



Industry 4.0

Not even industry 4.0 is capable of providing an answer for what concerns the critical factors of worst performers. If compared only to the sample, numbers seem to be really explicative, because just a small part of the worst firms apply industry 4.0 techniques, if compared to the sample. But if we extend the analysis to compare Worst and Top, results are baffling once again, since percentages are really similar.

Figure 67: Industry 4.0 – a comparison [n^w =19 ; n^t =26; n^x =248]



Thus, we cannot state that industry 4.0 is what really makes the difference.

Lean

An answer can be searched in lean implementation, but before drawing any conclusion we have to remember that numbers are not on our side.

Figure 68: percentage of lean among Worst companies[n^w =19]

Once again, they are too small[23] to be significant; anyway, an overall trend can be searched. The first step made was calculating the proportion of lean companies within the worst. Also here results are –theoretically– not so good, but not even too bad. In fact, 37% of the Worst firms does implement lean.

Going straight to lean practices implementation, it fortunately can tell something more than industry 4.0. In fact, if we look at 5S, Visual, and A3, the three practices most popular among Top firms, we notice that the gap between Top and Worst is here large. 5S and visual management were both applied by 82% of Top companies, whereas only 43% among the Worst implement these practices. Instead, none of the Worst implement A3, that was at 41%

[23] To recall: the number of Worst firms is 19, and among these 7 implement lean.

among the Top. The most applied technique among Worst firms are Pull, with 57% of cases (vs. 76% of Top), and Heijunka, that is instead implemented only by 29% of the Top (thus turning out to be not essential for good performance). Another change of direction concerns six sigma, the least implemented by Top firms (6%) here amounting to 29%. With the exceptions just mentioned, Worst firms implement, on average, lean practices 19% less than Top ones.

Figure 69: lean practices implementation – a comparison [n^w =19 ; n^t =26; n^x =248]

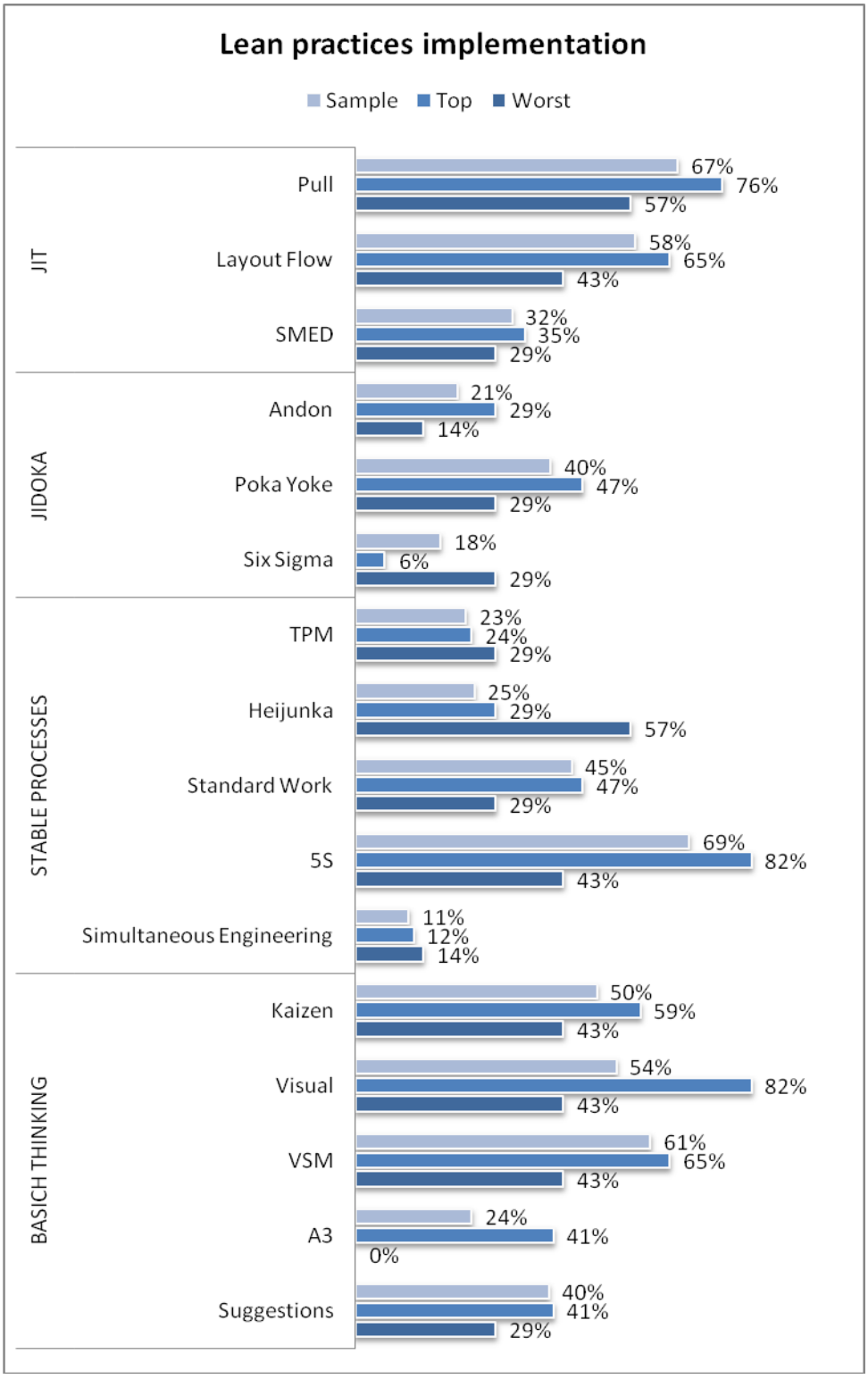
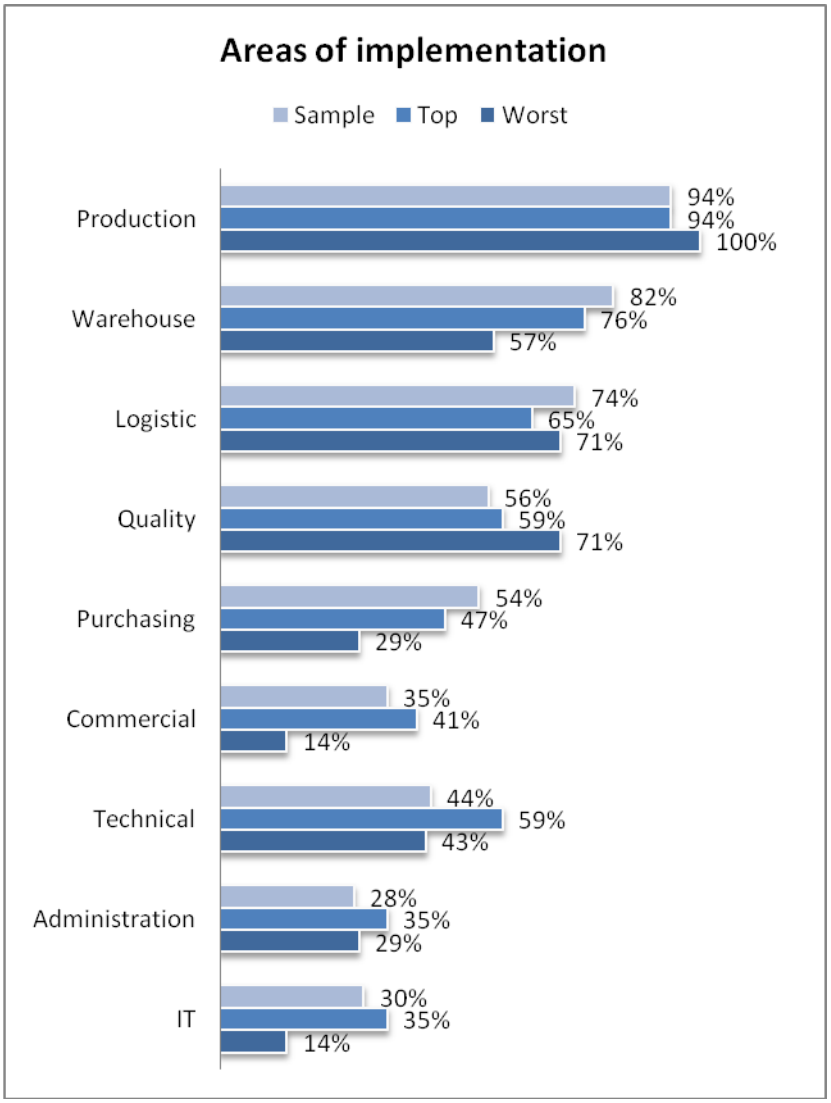


Figure 70: areas of lean implementation – a comparison [n^w =19 ; n^t =26; n^x =248]



For what concerns the areas of implementation, they are a little less explicative than the practices. Lean in production is implemented by all the 7 companies, but as the literature often remarks, being lean does not mean implementing it just in production. Companies sometimes expect great improvements just because they introduce one of the lean practice, but it is not enough. Logistic and quality are the two other areas in which Worst firms apply more lean practices with respect to Top, whereas for all the others the trend is the opposite, i.e. the percentage of Worst companies implementing lean is smaller than the percentage of Top companies, in particular for commercial office and IT, in which the gap is larger than 20%.

Conclusions

The analysis conducted in this chapter were made from the elaboration of data collected through the survey, in the hope of clarifying some linkages between firms' performance, characteristics, and lean implementation.

In the next chapter the results of the fsQCA analysis will be illustrated.

CHAPTER 4
fsQCA ANALYSIS

The previous chapter provided an overview about the characteristics of the sample gathered through the survey, analyzing various aspects of the respondent firms, and making comparisons between different subsets, i.e. lean and non-lean firms, top and top lean, worst and worst lean, and, finally, top and worst firms, with the hope of identifying critical success factors with regards to performance.

This final chapter will focus on lean practices implementation, being the goal of this research to identify which lean bundles better influence companies' performance.

4.1 THE METHOD

The method used is a fuzzy-set qualitative comparative analysis (fsQCA), implemented through the so-called fsQCA software, that makes use of Boolean algebra[24], and whose methods "represent each case as a combination of causal and outcome conditions" (Ragin, Charles, & Davey, 2016). Through the elaboration of a "truth table", this software provides information "regarding the different combinations of conditions that produce a specific outcome" (Ragin *et al*. 2016). The fuzzy-set side of this analysis is related to variable calibration, since it allows to transform each variable into a fuzzy variable, in this way going beyond the *true* or *false* outcome, or *belong* or *don't belong* typical of crisp sets (where only 0 or 1 outcome is possible), but rather assigning a degree of membership – indeed, between 0 and 1 –to each variable. (For further information please check <http://www.socsci.uci.edu/~cragin/fsQCA/software.shtml>.)

This qualitative comparative method is deemed appropriate for this kind of research, since it provides an answer to the question 'which lean bundles better influence performance', highlighting furthermore which combination is most suitable or, by contrast, which bundle is better to avoid in combination with others, for the purpose of reaching that specified outcome. In addition, Furlan and Galeazzo (2018) mention three advantages of fsQCA analysis over 'traditional methods, namely the fact that it assumes 1) conjunctural causation and 2) equifinality, and 3) that it allows for asymmetrical relations. The assumption of conjunctural

[24] In Boolean algebra the values of the variables are simply, true and false, usually translated as 1 and 0 respectively.

causation means that fsQCA considers the combined effects that a variable could produce, not trying to estimate its standing alone contribution; equifinality means that the different solutions provided (in case multiple solutions emerge) bring to the same outcome; finally, asymmetrical relations means that, if a combination of variables is linked to a certain outcome, the absence of these combination does not necessarily mean the same outcome won't show up. Moreover, the distinction between core and periphery variables (or bundles) allows for a better understanding of which bundles are more relevant in order to achieve that outcome.

Data

The input data used for this analysis were extracted from the sample gathered through the survey. In particular, out of the 248 valuable answers collected, we selected the 114 actually implementing lean practices. We further slim down the list by eliminating those who started lean after 2014, since benefits deriving from its implementation may not be visible yet. In this way, the number of firms narrowed to 77.

At first, the analysis was carried out on this sample of 77 firms, and in a second step on a restricted subset of 56firms, the latter corresponding to companies in which executives are involved in lean implementation, to understand whether top management involvement in these practices can have a positive impact.

In order to understand if lean truly benefit on performance, we took into account some financial indicators, deeming financial measures an objective way to assess performance. In particular, the mean of ROA and EBITDA/Sales over the last three years (2017-2015)[25] were set as outcome. In a further step, the analysis was made with the 'set negated' function, meaning the investigation was done on causal conditions leading to the absence of high performance (called, *low/bad performance*)

The variables tested in relation to these indicators are in line with the part of the literature that distinguishes between *hard* and *soft* lean. More precisely, to group practices into bundles, we made the distinction between *technical-oriented* (TO) practices and *continuous improvement* (CI) ones.

At the beginning of the previous chapter, three bundles were mentioned as part of further research, i.e. JIT, TQM, and TPM. Specifically, JIT was considered as Pull, Layout Flow, and SMED; TQM was meant as Jidoka, built of Andon, PokaYoke, and eventually Six Sigma;

[25] Values for the three years were downloaded from Aida database.

finally, TPM was considered as a standing alone bundle. The following step grouped JIT, TQM, and TPM in the single 'technical-oriented practices' bundle. With regards to the CI bundle, the practices considered were Kaizen, A3, Suggestions, Visual, Standard work, 5S, and VSM. Once these two overall bundles were established, the final subsets were built according to the implementation area. As illustrated in chapter 3, the implementation areas mentioned in the survey were production, warehouse, logistic, quality, purchasing, commercial, technical, administration, and IT. The data considered for fsQCA analysis were the ones relative to production, logistics, and purchasing. Six different variables were therefore created*: technical-oriented practices in production, technical-oriented practices in logistics, technical-oriented practices in purchasing, continuous improvement in production, continuous improvement in logistics, continuous improvement in purchasing*.

Calibration

As mentioned before, in fsQCA analysis each variable is commuted into a fuzzy variable, with values ranging from 0 to 1, mirroring the degree of membership of that variable to a subset. Zero corresponds to *full non-membership*, 1 to *full membership*, and values in between express the degree to which each case (firm, in this case) belong to that subset (e.g. more in rather than out, or more out rather than in). The function *calibrate(x,n1,n2,n3)* requires to specify three benchmarks "to transform the original ratio (...) into fuzzy membership scores" (Ragin C. , User's guide to Fuzzy-Set / Qualitative Comparative Analysis 2.0, 2008, p. 17). These benchmarks (n1,n2,n3) are, in order, the threshold for full membership, the cross-over point, and the threshold for full non-membership. Values used as benchmarks for this analysis were, respectively:

$mean + standard\ deviation$, $mean$, $mean - standard\ deviation$, calculated for each of the above-specified bundles. Both the six bundles and the outcomes (ROA and EBITDA/Sales) were calibrated in this way. In table 5 are reported the values of mean and standard deviation of the six bundles.

Table 5: mean and st.dev. of technical-oriented (TO) and continuous improvement (CI) bundles

	TO in production	**TO in logistics**	**TO in purchasing**	**CI in production**	**CI in logistics**	**CI in purchasing**
mean	2,9324	1,0270	0,3919	3,8108	2,0946	0,8649
standard deviation	1,8896	0,9789	0,5444	2,3738	2,0948	1,1506

Data Analysis

The next step was creating a truth table from the fuzzy data, through the 'truth table' algorithm. First $ROA_{2015-2017}$, and then $EBITDA/Sales_{2015-2017}$ were set as outcome, and the six bundles as causal conditions. The table elaborated by this algorithm represents all the possible combinations of conditions, and specify the number of cases in which a certain configuration is found (represented by the column 'number' in figure 71), the consistency (column 'raw consist.' in figure 71), and the coverage (since fuzzy sets allow each case to have a partial membership to the rows of the truth table). "The assessment of each combination of conditions is based on pattern observed across all cases, not on a small subset of cases." (Ragin C., 2008) In this analysis, the selected cut-off for the minimum number of cases to be present was 2, thus rows with less than 2 cases were eliminated. The minimum consistency score was set to 0.75, so all combinations with lower consistency were coded with 0, whereas combinations with consistency equal or above 0.75 were coded with 1 since it means they are cases "in which the outcome is consistently found" (Ragin C., 2008, p. 109). In figure 71 is reported an example of Truth table, in which the six bundles are tested by setting EBITDA/Sales as outcome.

Figure 71: Truth table

Edit Truth Table

File Edit

TOPro	TOlog	TOpurch	Cipro	Cilog	Cipurch	number	EBsal1715	raw consist.	PRI consist.	SYM consist
1	1	1	1	1	1	9 (13%)		0.757214	0.620813	0.727021
0	0	0	0	0	0	7 (24%)		0.64282	0.532893	0.532893
0	1	0	0	0	0	7 (35%)		0.845032	0.74376	0.74376
1	1	0	1	1	1	6 (44%)		0.892955	0.834726	0.834726
0	1	1	0	0	0	4 (50%)		0.67794	0.439396	0.439396
1	1	1	0	0	0	3 (55%)		0.844485	0.720742	0.720743
0	0	0	1	0	0	3 (60%)		0.777577	0.639251	0.639251
0	1	0	1	1	0	3 (64%)		0.960882	0.919775	0.919776
1	0	0	1	0	0	2 (67%)		0.745629	0.600519	0.600519
0	0	1	1	0	0	2 (70%)		0.84782	0.754544	0.754545
1	1	1	1	0	0	2 (73%)		0.875097	0.752325	0.788235
0	0	0	0	0	1	2 (76%)		0.78391	0.473409	0.487908
0	1	1	0	0	1	2 (80%)		0.827021	0.627743	0.627743
1	1	0	1	0	1	2 (83%)		0.885412	0.810814	0.810814
0	1	0	0	1	0	1 (84%)		0.946668	0.887318	0.887318
0	0	0	1	1	0	1 (86%)		0.899006	0.816255	0.816255
1	1	1	1	1	0	1 (87%)		0.9125	0.805036	0.805035
1	1	0	0	0	1	1 (89%)		0.924994	0.828176	0.828176

4.2 RESULTS

The output of the Truth table is represented by three solutions, namely complex solution, parsimonious solution, and intermediate solution, each "based on a different treatment of the remainder combinations" (Ragin C., 2008, p. 81). In this analysis, only parsimonious and intermediate solutions were considered, since in the complex solution counterfactual analysis is not used, whereas the other two kinds of solution do use it. Specifically, the parsimonious solution uses *difficult* counterfactual, whereas intermediate just *easy* ones. As Ragin and Sonnett state, *easy* and *difficult* counterfactuals are simply the two opposite of a continuum. The assumption beyond easy ones is that "adding a redundant causal condition to a configuration known to produce the outcome would still produce the outcome." (Ragin & Sonnett, p. 10) Difficult counterfactuals, in contrast, try to show that a causal condition is redundant by removing it from the combination and demonstrating the outcome does not change.

As mentioned at the beginning of this chapter, the fsQCA analysis distinguishes between core and peripheral solutions, represented, in the software, respectively by the parsimonious and intermediate solution. Specifically, core solutions are those essential for the realization of the outcome, whereas peripheral 'support' the outcome but are not essential. In figure 72 – illustrating results obtained through fsQCA software –core solutions are denoted by large circles, peripheral by smaller circles. Another distinction is between black and crossed-out circles: black ones entail the presence of that condition for the outcome to be achieved; crossed-out ones, by contrast, require that condition to be absent (must-not be present). Finally, empty spaces do not imply the causal condition is not present, but rather that it is a *don't care* condition, meaning that the presence or absence of it does not really affect the realization of the outcome. Each column in figure 72 represents a different combination leading to the specified outcome, and for each configuration consistency and coverage are indicated.

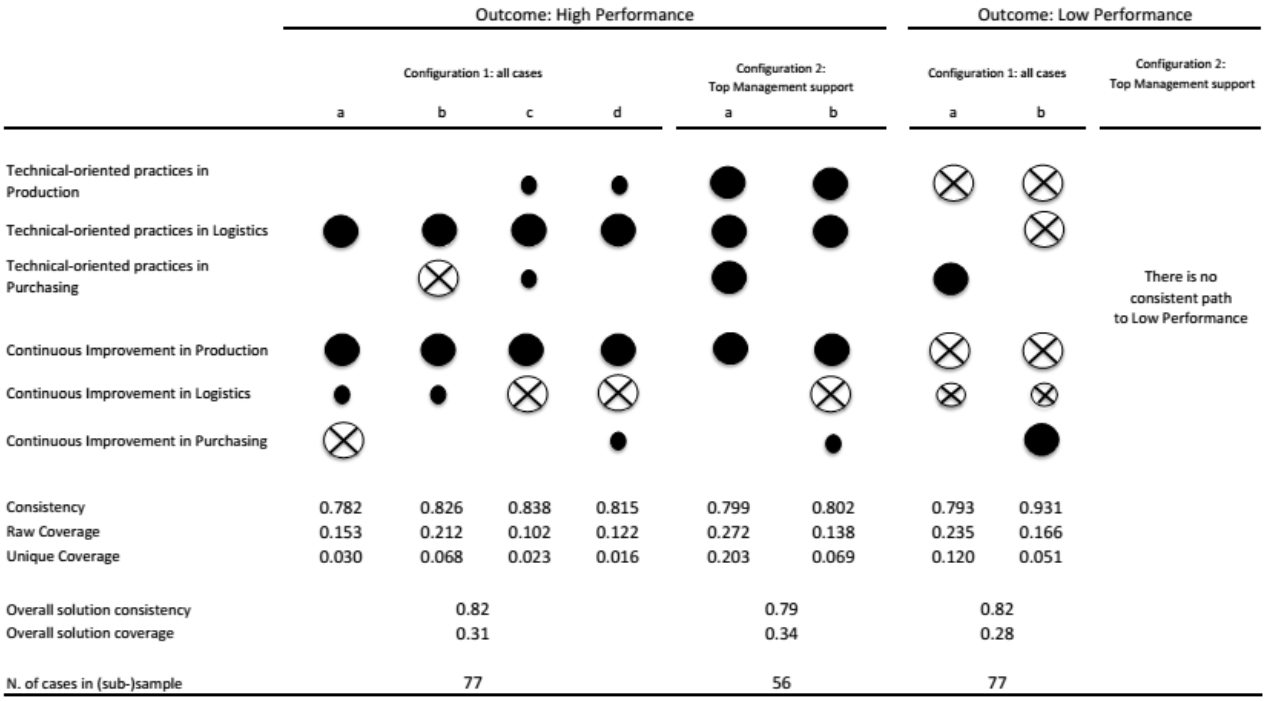
Here below are reported some useful definition about consistency and coverage:

- "*Consistency* measures the degree to which solution terms and the solution as a whole are subsets of the outcome" (Ragin C., 2008, p. 85) As previously said in this chapter, to be significant, consistency must be 0.75 or above.
- "*Solution coverage* measures the proportion of membership in the outcome that is explained by the complete solution."
- "*Raw coverage* measures the proportion of membership in the outcome explained by each term of the solution"

- "*Unique coverage* measures the proportion of membership in the outcome explained solely by each individual solution term (memberships that are not covered by other solution terms)." (Ragin C., 2008, p. 86)

As mentioned above, the six lean bundles were tested as causal conditions for the achievement of high EBITDA/Sales and high ROA, chosen as indicators for high performance. Only results concerning EBITDA/Sales are reported in this paper since they turned out to be more significant than those with ROA.

Figure 72: fsQCA results



Observing the different configurations that lead to high performance we can note six different combinations, four concerning the sample inclusive of all cases, and two with regards to the sample with executives involvement. These six combinations share a constant factor, namely the presence of TO practices in logistics and CI practices in production as core conditions. Focusing on the four solutions for the whole sample, two of them have CI in logistics as peripheral condition, and require the absence of lean (one in TO the other in CI) in purchasing. The other two have as peripheral TO in production and, one TO practices in purchasing the other CI. Moreover, these latter two solutions, require the absence of CI in logistics. Shifting to the configuration of firms in which executives support lean implementation, one combination envisages technical-oriented practices in all bundles and CI practices in production; the other is similar, except that instead of TO in purchasing as core

condition, has it in CI as peripheral, and CI in logistics must not be implemented. For what concerns configurations that lead to low performance, what stands out is the absence of whatever TO or CI practices in production and logistics, with the exception, in one case, of TO in logistics –that does not make any difference if implemented without the support of lean in production. In the same manner, in purchasing, once TO and the other CI practices, are present as core condition. With regards to companies with executives' support, no configuration leading to low performance is found.

Therefore, the overall message that emerges can be summarised in two key points. On one hand, all configurations show that to reach a high performance:

1) is essential to implement lean practices in production, logistics, and purchasing;
2) technical-oriented practices must be implemented alongside continuous improvement ones;

On the other hand, to have a low performance, lean practices in production and logistics must not be implemented.

With regards to the sample of firms in which executives are involved, both configurations show that to reach a high performance the focus must be on production and logistics; in contrast, there is no configuration leading to a low performance if executives are actively involved in lean implementation.

These results give a strong signal to lean companies: lean implementation can't be only technical-oriented, but continuous improvement should be deployed in order to achieve high financial performance. In particular with regards to production, CI practices seem to be more important than technical-oriented ones, being present –besides, as core condition –in all the six combinations resulting in high performance; the opposite is true for logistics, in which technical-oriented practices must be implemented (even, three combinations show that CI practices must not be applied in logistics). Already at this point, the importance of joint implementation of technical-oriented and continuous improvement practices is well visible, above all in production and logistics, since

a) in each configuration leading to high performance they are core conditions,

b) in each configuration leading to low performance these two must not be present.

With regards to companies in which executives support lean implementation, results tell us that there is not a consistent path to low performance. This does not mean that firms in which executives are involved cannot have a low performance, but rather that their involvement might positively influence lean implementation, and so performance.

Lean in purchasing, instead, plays a minor role with respect to lean in production and logistics, since it requires practices different from pure lean ones, more linked to supply chain management. While respecting the principle of a 'lean enterprise', we could state that in some cases lean is more about the guiding principles than not about the tools. This seems to be the case of purchasing, whose priorities are different from the ones of production and logistics.

The purchasing department is the link between operations and suppliers, and so it must be able to fully understand needs and capabilities of both sides. A first step an organization has to take is the *make-or-buy* decision, namely whether to perform internally a value activity or purchase it on the market. Within this make-or-buy decision, also *hybrid* forms are possible, represented by long-term business relationships between the buyer and the supplier. The more the business is based on pure market transactions, the higher the need of drawing up well-defined contracts regulating the transaction; by contrast, the more the business is characterized by long-term relationships, the more the under question relationship need to be nurtured. In this latter case, cooperation can, and should, lead also to co-development or co-innovation projects, that would benefit both entities. Once the make-or-buy decision has been made, the biggest decision concerns the supply base, defined as the group of suppliers. At the two extremes we find single-sourcing (only one supplier) and multi-sourcing (multiple suppliers), with the trend moving towards a small but stable supply base. Summarizing, the big challenge of the purchasing department is primarily to manage relationships both upstream and downstream the value chain, and this could be the reason why lean practices take second place in this organizational area; having a well-structured purchasing department but not being able to manage relationships makes no sense.

CONCLUSIONS

The lack of most studies is that they fail to capture the interdependency among multiple lean bundles. As Cua *et al*. (2001) already noticed at the beginning of the century, the majority of studies limited their analysis on the effect of a single lean bundle on performance. Since then, several scholars started to investigate the joint effects of lean bundles, most of the time combining two, sometimes three, different bundles, with JIT, TPM, and TQM being the most popular. Later on, also the HRM bundle started to be included in the research. Other scholars then started to broaden the focus, analyzing no more 'technical' bundles but simply distinguishing between hard and soft lean practices.

The aim of this paper is in line with all those scholars that are trying to assess whether there is a positive relationship between lean manufacturing and performance.

In chapter 3, the sample of firms gathered through the survey was described according to several points of view, as dimensional, sectorial, production-base, financial dimension. Comparisons between lean and non-lean firms, and between Top and Worst tried to catch some trends to explain companies' performance by relating it to some recurrent factors.

Chapter 4, is dedicated to an in-depth analysis of lean bundles and financial performance, with a focus on implementation areas. In this paper, the concepts of hard and soft lean mentioned above were slightly modified, by creating one bundle for technical-oriented practices, in some way comparable to the hard bundle, and another bundle for continuous improvement, containing all those practices linked to the concept of kaizen and ongoing improvement. Later on, these two bundles were tested in two different organizational contexts, that are companies in which executives are involved in lean implementation and companies in which they are not. In this way, the 'human resource side' of lean implementation is not measured looking at which practices or processes are used, but simply looking at top management involvement, not considering it as a bundle but as an organizational factor characterizing all firms in that (sub)set.

Once having identified the two overall bundles, we break them down by distinguishing between the three areas of implementation, namely production, logistics, and purchasing.

Contributions, limitations and further research

Almost all studies aim at understanding which practices better influence companies' performance, without specifying in which area/processes they should be implemented. This research moves the real focus from practices to implementation areas. This does not mean

lean practices are not considered, but simply that they gain weight only according to the implementation area (the weight given to each practice is the same[26]). Moreover, it highlights the importance of joint implementation of technical-oriented and continuous improvement bundles, while at the same time specifying which bundles are most suitable in each area (e.g. CI in production and TO in logistics turn out to be core conditions), and which combinations are the most effective. It provides in this way a useful framework for managers that have to deal with lean transformation, allowing them to focus their effort and resources in a determined area, showing which conditions are essential for the achievement of a high performance, and which are peripheral and so can take second place.

The second contribution of this paper stems from the use of the fsQCA method. The big majority of studies test the effect of lean on performance through a regression model. Regression, however, only captures the marginal contribution of bundles, not considering the interrelation between multiple bundles and so effects that originate only thanks to their joint implementation. Furthermore, as Furlan and Galeazzo (2018) underline, a regression model, in this case, assumes the marginal effects stemming from lean implementation are comparable in a company applying lean since many years and in one that is just engaging in lean transformation. A qualitative comparative analysis, instead, is able to capture these interdependencies between different bundles, by testing them through both easy and difficult counterfactuals.

Another contribution of this paper concerns top management support. Results tell us that, paradoxically, their involvement entails a higher degree of lean adoption, but that it is more difficult to embark upon a wrong path in case of involvement of the upper hierarchical levels. Often, in the literature, the lack of managerial commitment or the misunderstanding of lean principles are pinpointed as the cause of lean failure.

This result can, in some way, prove this theory, by demonstrating the absence of a 'consistent path' to low performance in case of top management involvement.

Further research could focus more on this topic, trying to define which are the most important aspects of top management involvement in lean manufacturing. Our data about their involvement, in fact, is just a *Yes/No* answer to the question asking whether they were involved, but no further investigation was carried on, nor was asked to which degree they were involved.

[26] For example, if one practice among Pull, layout flow, SMED, Six sigma, Andon, Poka Yoke, or TPM is implemented, the value of the TO bundle is 1/7 (then calibrated).

Another in-depth analysis could investigate which practices are most suitable in which area. According to the method used in this research, the final solution doesn't provide an answer with regards to which are the most suitable practices in detail, but rather that, for example, one between the technical-oriented practices should be implemented in that organizational area. Another analysis, therefore, could follow by further breaking down bundles in order to understand in detail which practices are suitable in which areas. Moreover, more and different bundles can be considered, as well as different organizational areas can be taken into consideration to do more research. Different indicators of performance can likewise be considered, not necessarily financial ones, but also market-related.

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APPENDIX

Appendix 1

Table 2: Research summary in the area of lean impact on organizational performance. Source: Belekoukias, Garza-Reyes, & Kumar (2014)

Authors	Lean and associated practices/tools		Impact on (measure)	
Rahman, Laosirihongthong, and Sohal (2010)	• Reduction of inventory • Preventive maintenance • Cycle time reduction • Use of new process technology • Use of quick changeover techniques • Reducing setup time	JIT	(1) (2) (3) (4)	Quick delivery compared to the main competitor Unit cost of the product compared to competitors Overall productivity Overall customer satisfaction
	• Eliminate waste • Use of error proofing techniques (Poka-yoke) • Using pull-based production system (Kanban) • Remove bottlenecks	Waste minimisation		
	• Reduce production lot size • Focus on single supplier • Continuous/one piece flow	Flow management		
Shah and Ward (2007, 2003)	• JIT • Total Quality Management (TQM) • Total Productive Maintenance (TPM) • Human Resource Management • Contextual factors: plant age, plant size, unionisation		(1) (2) (3) (4) (5) (6)	Five year changes in cycle time Scrap and rework costs Productivity of labour Customer lead time First pass yield Unit manufacturing costs
Bhasin (2012)	• Lean manufacturing (as overall approach)		(1)	Balanced Scorecard (financial and operational efficiency)
Cua, McKone-Sweet, and Schroeder (2006)	• Cross-functional product design • Process management • Supplier quality management • Customer involvement	TQM basic techniques	(1) (2) (3) (4)	Quality Flexibility Cost Delivery
	• Setup time reduction • Pull system production • JIT delivery by suppliers • Daily schedule adherence	JIT basic techniques		
	• Autonomous and planned maintenance	TPM basic techniques		

(*Continued*)

Table 2. (*Continued*).

Authors	Lean and associated practices/tools		Impact on (measure)
	• Technology emphasis • Proprietary equipment development		
	• Committed leadership • Cross-functional training • Employee involvement • Information and feedback • Strategic planning	Human and strategic oriented common practices	
Taj and Morosan (2011)	• Human resources • Supply chains • Design of production systems		(1) Flow (2) Quality (3) Flexibility
Lawrence and Hottenstein (1995)	• Reduction of setup times • Reduction of production lot sizes • Reduction of inventories • Simplification of materials flow and handling • Prevention of defective products	JIT practices	(1) Quality (2) Customer service (3) Lead time (4) Productivity
Thun, Drüke, and Grübner (2010)	• Lean manufacturing (as overall approach)		(1) On time delivery (2) Inventory turnover (3) Flexibility to change volume (4) Product conformance (5) Cycle time (6) Cost
Bortolotti, Danese, and Romano (2013)	• Pull production systems • Lot size reduction • Cellular layout • Setup time reduction • Daily scheduled adherence • JIT delivery by suppliers	JIT practices	(1) Inventory turnover (2) Cycle time (3) Unit cost (4) On time delivery (5) Product volume (6) Product mix flexibility (7) Fast delivery
Searcy (2009)	• Lean manufacturing (as overall approach)		(1) Quality (2) Capacity (3) Productivity (4) Inventory (5) Cost
Fullerton and Wempe (2009)	• Shop floor employee involvement in the problem solving process • Cellular manufacturing • Setup time reduction • Quality improvement		(1) Financial measures

(*Continued*)

Table 2. (*Continued*).

Authors	Lean and associated practices/tools		Impact on (measure)	
Hallgren and Olhager (2009)	• Lean manufacturing (as overall approach) • Agile manufacturing (as overall approach)		(1) (2) (3) (4) (5)	Cost Volume flexibility Quality Product mix flexibility Delivery dependability
Behrouzi and Wong (2011)	• JIT • Waste elimination		(1) (2) (3) (4)	Quality Cost Time JIT delivery
Rivera and Chen (2007)	• Waiting time • Activities duration • Reduction of material • JIT materials		(1)	Cost-time investment of a product
Dora et al. (2013)	• Lean manufacturing (as overall approach)		(1) (2) (3) (4) (5)	Productivity improvement Inventory reduction Cycle time or lead time reduction Quality improvement On time delivery
Hofer, Eroglu, and Hofer (2012)	• Pull • Flow • Setup • SPC • Employee involvement • TPM	Internal lean practices	(1) (2)	Financial performance Mediating role of inventory leanness in the relationship between final performance and lean production
	• Supplier feedback • Supplier JIT • Supplier development • Customer involvement	External lean practices		
Karim and Arif-Uz-Zaman (2013)	• Lean manufacturing (as overall approach)		(1) (2) (3) (4) (5)	Effectiveness Defect rate Efficiency Productivity Value added time ratio
Sakakibara et al. (1997)	• Setup time reduction • Maintenance • Kanban • Equipment layout • JIT supplier relationships • Scheduling flexibility	JIT practices	(1) (2) (3) (4) (5) (6) (7) (8)	Inventory turnover Lead time On time delivery Cycle time Quality Flexibility Unit cost Plant's management opinion for the performance of the plant compared to global competition
	• Quality management • Manufacturing strategy • Product design • Workforce management • Organisational characteristics	Infrastructure practices		

Appendix 2

Table 3: Hard and soft LM practices. Source: Bortolotti, Danese, & Boscari (2014)

Practice	LM literature	Literature on hard/soft practices	Hard/soft LM practice
Setup time reduction	Flynn et al. (1995), Cua et al. (2001), Shah and Ward (2003), Shah and Ward (2007), Matsui (2007),Mackelprang and Nair (2010)	Rahman and Bullock (2005)	Hard LM practice
JIT delivery by suppliers	Cua et al. (2001), Shah and Ward (2007), Matsui (2007),Mackelprang and Nair (2010)	Rahman and Bullock (2005)	Hard LM practice
Equipment layout for continuous flow	Cua et al. (2001), Shah and Ward (2003), Shah and Ward (2007), Matsui (2007),Mackelprang and Nair (2010)	Rahman and Bullock (2005)	Hard LM practice
Kanban	Flynn et al. (1995), Cua et al. (2001), Shah and Ward (2003), Shah and Ward (2007), Matsui (2007),Mackelprang and Nair (2010)	Rahman and Bullock (2005)	Hard LM practice
Statistical process control	Flynn et al. (1995), Cua et al. (2001), Shah and Ward (2003), Shah and Ward (2007), Matsui (2007)	Samson and Terziovski (1999), Rahman and Bullock (2005), Taylor and Wright (2006), Fotopoulos and Psomas (2009)	Hard LM practice
Autonomous maintenance	Cua et al. (2001), Shah and Ward (2003), Shah and Ward (2007), Matsui (2007),Mackelprang and Nair (2010)	–	Hard LM practice
Small group problem solving	Flynn et al. (1995), Shah and Ward (2007), Challis et al. (2005), Matsui (2007)	Samson and Terziovski (1999), Lagrosen and Lagrosen (2005), Prajogo and McDermott (2005), Rahman and Bullock (2005), Taylor and Wright (2006),Fotopoulos and Psomas (2009)	Soft LM practice
Training employees	Flynn et al. (1995), Cua et al. (2001), Shah and Ward (2003), Shah and Ward (2007), Matsui (2007)	Samson and Terziovski (1999), Lagrosen and Lagrosen (2005), Prajogo and McDermott (2005), Rahman and Bullock (2005), Taylor and Wright (2006),Fotopoulos and Psomas (2009)	Soft LM practice
Top management leadership for quality	Flynn et al. (1995), Cua et al. (2001), Matsui (2007)	Samson and Terziovski (1999), Lagrosen and Lagrosen (2005), Prajogo and McDermott (2005), Taylor and Wright (2006), Fotopoulos and Psomas (2009)	Soft LM practice
Supplier partnership	Flynn et al. (1995), Cua et al. (2001), Shah and Ward (2007), Matsui (2007)	Rahman and Bullock (2005), Fotopoulos and Psomas (2009)	Soft LM practice
Customer involvement	Flynn et al. (1995), Cua et al. (2001), Shah and Ward (2007), Matsui (2007)	Samson and Terziovski (1999), Prajogo and McDermott (2005), Rahman and Bullock (2005), Taylor and Wright (2006),Fotopoulos and Psomas (2009)	Soft LM practice
Continuous Improvement	Shah and Ward (2003),Matsui (2007)	Samson and Terziovski (1999), Lagrosen and Lagrosen (2005), Fotopoulos and Psomas (2009)	Soft LM practice

Appendix 3

Survey*

SECTION 1

1) Name of the company
2) Turnover 2016
3) Percentage of 2016 turnover realized abroad
4) Number of employees
5) Percentage of blue collar on total number of employees
6) Is the company a family business? (With family business we mean owners are directly involved in the management)
    a. Yes
    b. No
7) In which province is located the operational headquarter?
    a. Belluno
    b. Verona
    c. Padova
    d. Vicenza
    e. Rovigo
    f. Treviso
    g. Venezia
    h. Other (please specify)
8) Does the firm have manufacturing facilities abroad? If it does, where are they located?
    a. No plant abroad
    b. Africa
    c. Europe (excluding Russia)
    d. Russia
    e. North America
    f. Latin America
    g. Asia (excluding China)
    h. China
    i. Oceania
9) Indicate the percentage of turnover 2016 for each type of customer:
    a. Final consumers
    b. Distributors
    c. Industrial firms
    d. Others
10) Please indicate which country represent the main market and the percentage of revenues 2016 here realized
11) How many workers, in percentage on the total of workers, are able to work in more than one workstation (job rotation)?

**The survey was sent in Italian to companies, and then has been translated in English for this paper.*

12) How many product families have been realized in 2016? (With family product we mean a group of products manufactured through a similar production process and by the same machines)?
13) Please indicate which percentage of the total sales falls within the following categories:
    a. Design to order
    b. Manufacture to order
    c. Assembly to order
    d. Make to stock
14) Indicate which of the following is your productive layout
    a. Fixed-position layout
    b. Functional layout
    c. Cell layout
    d. Line layout
15) Does the firm implement one or more of the following technologies (industry 4.0)?
    a. Robot in production
    b. Additional manufacturing
    c. Laser cutting
    d. Big data
    e. Scanner 3D
    f. Augmented reality
    g. Internet of things
    h. None/Smart products

SECTION 2

16) Do you apply any lean technique?
    a. Yes
    b. No
17) In which year did you start implementing lean techniques?
18) Why you start implementing lean?
    a. Specific requests of clients
    b. Request of banks/financers
    c. Need of improvement of economic/financial performance (crisis, restructuring, ...)
    d. Need of improving operational performance (services, efficiency, quality, ...)
    e. Willingness of the directors to modify the management rationale
    f. Imitation of clients/suppliers
    g. Other (please specify)
19) There are figures internal to your firm explicitly dedicated to lean techniques implementation?
    a. Yes
    b. No
20) Do you refer also to external consultants for lean techniques implementation?
    a. Yes
    b. No

21) Lean techniques are implemented also abroad?
    a. Yes
    b. No
    c. We don’t have any facility abroad
22) Indicate which of the following tools are implemented in which areas

	Production	Warehouse	Logistics	Quality	Purchasing	Commercial	Technical office	Administration	IT
VSM									
5S									
A3									
Pull/ Kanban									
Layout flow									
Visual									
Standard work									
Kaizen									
Poka Yoke									
TPM									
Suggestions									
Simultaneous engineering									
Heijunka									
Six sigma									
Smed									
Andon									

23) Which figures are actively involved in lean transformation?
    a. Owers/CEO
    b. Executives
    c. Managers
    d. Other (please specify)

24) Who is the main supporter of lean implementation?
    a. Owers/CEO
    b. Executives
    c. Managers
    d. Other (please specify)
25) In which kind of education did you invest?
    a. Master/Training courses for executives/managers/employees
    b. Workshops/Training courses for workers
    c. Other (please specify)
26) Which percentage of employees is involved in lean projects?
27) In your company, do you use any suggestion system?
    a. Yes
    b. No
28) Are workers directly involved in the improvement process?
    a. Yes
    b. No
29) In percentage, how many suggestions received from workers are actually implemented?
30) Which percentage of the 2016 turnover was invested in lean projects realized in 2016?
31) Which among the following, better explain your approach to detect errors and abnormalities?
    a. The quality control office is the responsible
    b. Workers are the responsible, but they are not allowed to stop the production line
    c. Workers are the responsible, and they stop the production undertake corrective actions
    d. Other (please specify)
32) Which among the following, better explain your approach to allocation of responsibility and supervision tasks?
    a. Responsibility is centralized, supervision and control is on the department chief
    b. Responsibility is decentralized, supervision and control are on the team members
    c. Responsibility is decentralized, supervision and control are on the team and are allocated to all the members in rotation
    d. Other (please specify)