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"PROACTIVE BEHAVIOURS AND MENTAL MODELS AS THE ROOT OF CONTINUOUS IMPROVEMENT"

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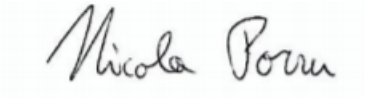

Alla mia famiglia, il rifugio sicuro della mia vita

Alla mia ragazza, per essere sempre al mio fianco

Ai miei amici, fidati compagni di mille avventure

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ABSTRACT

All continuous improvement initiatives like Total Quality Management, Lean Management and Six Sigma ultimately rely on employees' proactive behaviours. However, operations management and operational excellence literature rarely address this, nor recognizes its importance for the success of these management systems. In this thesis, after an introductory overview of lean philosophy, a multilevel theoretical framework is developed, linking proactive problem solving (PPS) and proactive idea implementation (PII) to team effectiveness in organizational routines. Moreover, we have investigated whether shared mental models (taskwork and teamwork SMM) within teams have a direct positive effect on employees' proactivity, as well as an indirect effect on team performance through the above-mentioned proactive behaviours. We argue that these shared cognitive structures facilitate communication and coordination within teams, stimulating employees to take an active role in their working activities and improving routine performances. Using a sample of 77 operators and 12 team leaders, the author has tested these hypotheses through a survey, developed after an in-depth review of knowledge management, operations management, and behavioural psychology literature. Ordinary Least Squares multiple regression models, conducted on the questionnaire's results, confirmed a significant and positive relationship between taskwork SMM and PPS and a negative effect of teamwork SMM on team effectiveness.

Keywords: lean, continuous improvement, proactivity, shared mental models, routine effectiveness

INTRODUCTION

Today's business world is characterized by intense competition, blurred industries' boundaries, fast moving environments and technologies. Organizations are required to quickly adapt to these ever-changing conditions and constantly search for new opportunities to obtain competitive advantages. In particular, firms must be able to continuously improve and always find new ways to face competition, because long-lasting market leader positions are fewer and more fragile than ever. Examples of these efforts are the implementation of world class manufacturing and improvement initiatives like TQM (total quality management), six sigma and lean management systems. All have the purpose of streamlining business processes, reduce defects and errors, enhance customer experience and engage in better supply chain management, although they differ in their methods. What they also have in common is that their success ultimately relies on employees to engage in proactive behaviours in their working activities: take on responsibilities of what they do, positively challenge the *status-quo*, participate and contribute to team's decisions, go beyond their normal assignments and detect improvement opportunities that lie behind problems.

However, operational management literature does not stress enough its importance nor it suggests how firms can generate or support this type of behaviours among their employees. The objective of this thesis is to analyse a potential fundamental driver of proactivity: the existence and strength of shared cognitive structures within teams where each individual works, called shared mental models. We will try to demonstrate that there is a positive correlation between these shared mental models and proactivity, as well as that both have a significant positive effect on team effectiveness during organizational routines.

The present work is articulated in three main chapters. The first one introduces the topic by depicting a general overview of one of the best improvement initiative and management system: the lean philosophy. Indeed, this was the one I was most interested in and which I had a direct and personal contact with during my university experience. The chapter will briefly present the system starting from its history, definition and main concepts. A large part will be dedicated to explain the five lean principles and the correspondent techniques that constitute its foundations. The second main section examines current relevant literature on operations management, organizational behaviour and applied psychology to outline the concepts of proactivity, organizational routines and mental models. Following Parker et al. (2006), we will refer to two important dimensions of proactive behaviour (proactive problem solving and proactive idea implementation) while mental models will be distinguished into taskwork and teamwork, a

terminology retrieved from Mathieu et al. (2000). Against this background, a theoretical model is developed, directly linking all these constructs with team performances in organizational routines. Moreover, it is claimed that taskwork shared mental models have a positive indirect effect on team effectiveness through enhanced proactive problem solving, while shared teamwork mental models have a positive indirect effect on team performance via improved proactive idea implementation.

Finally, the hypotheses formulated in the previous chapter are going to be tested empirically. Two manufacturing firms from the Italian Veneto region provided a statistical sample of 12 teams for a total of 77 operators and 12 team leaders. A survey will be administered to each of them and divided in sections with questions relative to each construct of the theoretical model. The results of the questionnaires will be used to run an OLS regression model and then interpreted to provide new insights and contribute to the existing body of literature on proactive behaviours, namely by providing evidence for the potential effects that mental model similarity might exert on team effectiveness, both directly and indirectly, through the encouragement of employees' proactivity.

1. THE LEAN SYSTEM

The lean management system has become the paradigm for many manufacturing and service firms around the world. Despite requiring a considerable effort in the application of the tools and in the adaption to a new organizational culture, its implementation has been quite successful. The best performing firms were those that embraced the larger transformation, in the long term, into a lean enterprise, an organization that delivers value to all its stakeholders, with little or no superfluous consumption of resources (Tiwari, Dubey and Tripathi, 2011). Empirical results, expressed in a sizeable portion of literature, are incredible (Bhasin, Burcher, 2006): up to 90% reduction of inventories and space utilization, up to 90% decrease in lead time, productivity push from 15 to 40% (including human resources), cost cutting between 15 and 70%, consistent quality improvement up to 80%. These statistics, of course, vary according to the industry, the degree of lean adoption, the firm's characteristics and starting point. Still, the leam system and philosophy allows any organization, anywhere, to achieve better performances, solid competitive positions and sustainable strategic advantages.

This first chapter will be devoted to the explanation of what lean management is, to let the reader understand how these outstanding results can be obtained. To do this, it is important to make a quick excursion into its history, to have a look at the origins and the men responsible for its creation. Then, a definition of lean and of the three main types of wastes that the system aims at eliminating (*muda*, *mura* and *muri*) is provided. A large part will be dedicated to illustrate the five fundamental principles of the system, along with the corresponding most important techniques. The chapter will end reviewing how lean has expanded outside the world of car manufacturing, where it was born, to eventually become universal.

1.1 History of lean management

The term *lean* was devised in the summer of 1987 in an office of the Massachusetts Institute of Technology. Daniel T. Jones, Daniel Roos, James P. Womack[1] and some researchers of the MIT were about to publish their first article on the findings of the International Motor Vehicle

[1] Jones is an English author and researcher, Shook is an industrial anthropologist and Womack is deemed the father of the lean movement. All of them have provided several important contributions to this management system

Program[2]. They visited and analysed almost 40 plants, operated by about 15 companies belonging to every continent except for Africa. Toyota's ones, as well as some other Japanese owned and several Ford's in North America were the best performers (high quality, high productivity, higher mix complexity).

They realized they needed a comprehensive, yet simple, wording to describe the management system they were observing in these superior performers of the automobile industry. The inspiration came from the writing of a list of all the performance attributes of the Toyota Production System (from here on the TPS), compared with the ones of traditional mass production. It was clear that the first was superior in every field: less human effort, fewer investments, lower number of suppliers and less inventory for higher cost efficiency, more productivity, wider variety and higher customer satisfaction. The TPS was capable of creating a given amount of value with fewer resources, whatever they might be. Hence, they called it *lean production*, thanks to the tip of one of the engineers, John Krafcik. Feeling confident with an ever-growing database of almost 70 plants from 14 different countries, he published the article that summarized all these findings: "Triumph of the Lean Production System" (Krafcik, 1988). The term lean was loose in the whole world, although it was made popular by the book "The machine that changed the world" (Womack, Jones and Roos, 1990).

Some of the main ideas of lean, though, were already being practised several centuries ago (Womack, 2013), even if for short periods of time before being completely forgotten. This is why the real history of lean management begins in 1574, when the concept of continuous flow of production processes was adopted by the Venetian Navy to build its warships. The galleys had a standardized design and were composed of interchangeable parts, all typical characteristics of a lean production. Another example occurred in 1765, when French general Jean-Baptiste de Gribeauval utilized these same ideas to facilitate battlefield repairs, although still not perfectly in terms of cost-efficiency.

In 1776, John Smith published The Wealth of Nations, describing the division of labour. Its application allowed for a sharp increase in productivity and spurred the introduction of numerous technological innovations that provided a significant improvement in the precision and velocity of production machinery. In the early years of the 19th century, Marc Brunel in England and Thomas Blanchard in the United States both proved the benefits of automated machines that utilized little, if any, human effort, and of cellular arrangements capable of

[2] The IMVP was a research program of the MIT with the aim of comparatively assess manufacturing performances, in particular the differences between the production systems of American and Japanese automobile industries

processing items one at a time in a smooth flow from beginning to end. The latter is, indeed, an important piece of a lean transformation for any production area.

In 1914, Henry Ford eventually fine-tuned all these lean ideas, then he combined and embodied them in his Highland Park plant, in Detroit (Michigan, USA), reaching level of performances never seen before. He obtained continuous flow by involving his suppliers in the process, so that metal parts consistently fit perfectly with Ford's fabrication cells. Go/no-go gauges were installed to catch defective parts, solving American armouries problem of unpredictable warping that needed to be corrected by hand, causing the production to stop. Other important features were the complete interchangeability, a cellularized fabrication with operations located in process sequence, a crude pull system and standardized work practises. Finally, he and his associates were also the first to focus on value creation, rather than assets or organizations, a systematic thought for lean experts.

In 1924, in the Toyoda Automatic Loom Works Ltd., Sakichi Toyoda, a Japanese entrepreneur, introduced in his factories textile looms that did not produce any defects (the model G), because as soon as threads broke they immediately stopped in order to be substituted. This invention drastically diminished scraps and made machine supervision much less demanding. This is another lean pillar: the machine is capable of detecting abnormal conditions and stop its work if necessary. Sakichi also contributed to the development of TPS by bringing a philosophy of hands-on hard work and continuous self-improvement.

By the late 1930s, the German aircraft industry had pioneered *takt*[3] *time* as a way to synchronize final assembly: airplane fuselages were moved ahead in the process in unison at a precise measure of time, dictated by the actual demand.

Meanwhile, Sakichi pushed his son Kiichiro to found a car company, fully aware that power looms would become obsolete whereas automobiles were the future. The Toyota Motor Company was born, under the inspiration of the family ideals. Unfortunately, the company heavily suffered the consequences of World War II: it lost 60% of its workforce, in an attempt to cut costs, and was facing a serious problem of overproduction. The following crisis forced Kiichiro to resign, who took responsibility for what happened even though the causes were far beyond his control. His younger cousin Eiji succeeded him, but still needed a reliable way to get the firm back on track very quickly. He then decided to learn the business ways of the three big players of the automobile industries: General Motors, Ford and Chrysler. In particular, he set out for a three months pilgrimage to visit Ford's River Rouge plant, the biggest in the world at the time. There he learnt the principles of mass production and its three key success factors:

[3] *Takt* is a German word that means meter. It is the only German term in the lean literature

the above-mentioned continuous flow in the production and assembly process; the scientific method of constantly analysing and measuring every operation to maximize efficiency; the concept of internal standard, both of the product and the process.
In the 1950s, Toyota Motor Company started to recoup some of its losses, but inevitably faced the fact that the Japanese market was very different from the American one. It was limited in terms of resources and number of consumers, demand was not homogenous, culture was more collectivist rather than individualist and the effects of the war had had a brutal outcome on the country's economy. Moreover, Toyota had no cash nor any economies of scale to sustain a mass production process. It was necessary to develop a different system to accommodate for these peculiarities: the TPS. The system incorporated two other fundamental concepts, among other minor ones, identified and mastered by the manager Taichi Ohno, the real mind behind the project:

- Just In Time (or simply JIT)
  The idea of producing and delivering in small quantities, with short lead times, to meet specific customer needs at their desired time. The power of JIT lies in the capability of being responsive and flexible to the day-to-day shifts in customer demand

- *Jidoka*
  Automation with a human touch. Processes have built-in quality because they do not generate any defects, as they are able to identify them and immediately stop to allow reparations. People are freed from the machines, however they must have the possibility to signal a problem and stop the work and the problem solving skills to act on them autonomously

Firm performances skyrocketed in the following years, thanks to the offering of good quality products in a very efficient way. This allowed the company to expand, initially on a local base, but eventually on a global level (such as in the United States and Europe) and it quickly gained large market shares in every served country. General Motors noticed its success and proposed to found a 50/50 joint venture with Toyota, called NUMMI (New United Motor Manufacturing Incorporation), in which the first provided the plant, while the second offered knowledge and help with its people. From being one of the worst, the factory took only two years to become one of the best in the world.
It was in that period that Womack, Jones and Roos commenced their analysis, stunned by the great achievements of Toyota. The main concepts of the TPS were scrutinized and evolved in the lean production system. Along with the various techniques, they were adapted to exit the

automotive production process, embracing all the other firm functions and expanding into several other industries. Lean became a real and universal management system, though deeply rooted in the Toyota way.
What is, then, lean? What are its main principles? What is the economic rationale behind it? The next sections are dedicated to explain these topics more in detail.

1.2 A definition of lean

More with less. I think this would be a good answer where to start if someone asked me to summarize the core idea of lean in less than five words. The ultimate purpose is to generate and maximize value for customers by delivering exactly what they want, in the requested quantities, precisely when and where needed, at the lowest price possible. Properly applying lean techniques and becoming a truly lean organization allows companies of all kinds, from any sector or country, to achieve this goal using lower and lower amounts of resources, being them people, machines, raw materials and so on.
Many authors have noted that a clear definition does not exist (Bhamu, Sangwan, 2014) and, indeed, a lot have proposed their own. According to Samuel, Found and Williams (2015) they can all be grouped under four main themes: an ideological movement that has emerged and progressed over time; a generic representation of the Toyota Production System; a process improvement methodology for an organization to use and follow; a polarized body of academic literature that has developed over time. Let us see them one at a time.
Firstly, lean can be described as a philosophical movement, composed of a set of coherent principles, which are focused on guaranteeing a smooth and regular flow of items (materials, information, customers) through processes. It was born with “The machine that changed the world” and evolved over time, but the core issues have remained the utter elimination of waste in every phase, the involvement of people in the operation and the drive to continuous improvement. The philosophical feature is proved by the existence of several organizations whose sole purpose is to spread and promote these ideas.
Secondly, lean can be seen just as a more generic and less culturally specific representation of the TPS, in an attempt to extract the Toyota methods out of its country’s context. In this sense, lean is a planning and control operations methodology that draws on the Japanese car manufacture principles to make them universally applicable, so that every organization can

benefit from the clear advantages it brings without being limited by the different geographic, political, social and economic characteristics.

Thirdly, lean is viewed as a set of best practises that any organization can follow to improve its processes and the ones of the wider supply chain it belongs to. Here, the attention is pointed at the fact that their goal is itself the improvement toward the elimination of waste in a continuous way. There is no such thing as the one best way and, even if it were, it would only be temporary.

Finally, from the literature point of view, lean is a collection of academic papers and studies on organizational, behavioural and management topics. Throughout the years, it evolved, addressing its initial weaknesses, incorporating new data and expanding out of the production world to include all the other functional department, also outside of the manufacturing sector.

Despite all these definitions, the *fil rouge* is just one and it is quite clear to everybody: waste must be cut out, everywhere. For this reason, the first step in understanding lean is to know what the Japanese words *muda*, *mura*, *muri* mean.

1.3 *Muda*, *mura*, *muri*

Muda, *mura and muri* are Japanese words that depict the concept of waste, in particular its three main types. The requirement to reduce or eliminate them is driven not only by economic reasons, as stated by the lean methodology, but also by an ethical and social meaning embedded into them. The Japanese society has been poor since just a few decades ago and its ideas about waste were very different from those of the rich Western ones. The latter considered it as no more than an inconvenient, a negative aspect that should be avoided, of course, but only secondary because it did not alter the social balance. On the contrary, for Japanese people, waste can be compared to the sin of the catholic religion and, for this reason, the effort and commitment to fight and erase it are much stronger. Ohno was the personification of this battle against waste, since he dedicated his life to ban it, without exception nor rest.

More in detail, *muda* is defined by Womack and Jones (1996, p.13) as “any human activity that absorbs resources but does not generate any value for the consumer”. This is the most famous among the three in the literature and common knowledge, as it is an easier place where to start: many types of *muda* can be removed from small areas without the need to coordinate with the whole organization or across firms within the supply chain network. For example, changing the layout of a process could be done without asking the permission to the broader production

system. Unfortunately, not enough attention is given to the other two causes of waste, as all of them are strictly related and enhance each other.

Mura means lack of consistency or unevenness in demand and in the internal processes. This waste is not caused by the end customer, rather it is due to scraps that climb back the production process, extra productions, irregularities in the demand pattern (because of seasonality, for instance) or poor standardization. This has serious consequences in terms of dependability and flexibility of the firm's operations: a misalignment between sales and production undermines the results of the activities.

Muri literally means absurd or unreasonable. The idea is that waste derives from unnecessary or unreasonable requirements put on people or processes. Likely related problems are inappropriate staff skills, unrealistic or ineffective planning activities, poor prioritization and scheduling of process phases. All will generate some level of overburdening of people or equipment, which will produce, at best, mediocre outcomes, on top of safety and quality problems.

Muda is always the starting step for many firms. However, unevenness in sales and production (*mura*) will cause employees and processes to work differently, too hardly, to stay on track (*muri*) which eventually will lead to an organization incapable of eliminating its wastes (*muda*) (Slack, Brandon-Jones and Johnston, 2016). *Mura*, indeed, is called the mother of all wastes. For these reasons, a better plan should be to evaluate the variations in the company's activities and assess whether they are desirable for the customers. If the answer is negative, smooth or eliminate them; otherwise, find ways to stabilize and maintain a balance between sales and production. This will help in cutting some overload and the rest should follow the same path. Once *mura* and *muri* are banned, removing *muda* will be much faster and it will be a permanent effect.

Knowing how *muda* can be eliminated requires a deep understanding of its various types that can be found in any organization. Ohno (1988) provided a list of seven (Figure 1.1), widely accepted in the lean community and considered an excellent guide for action. The acronym TIMWOOD helps memorizing them:

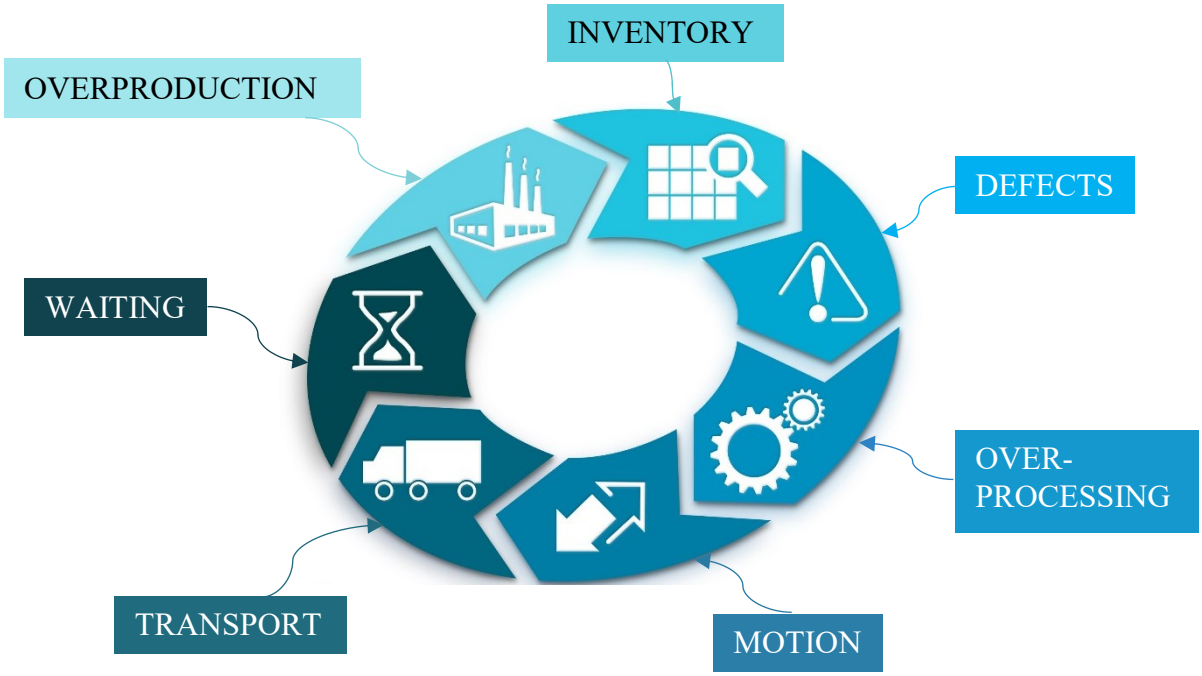

***Figure 1.1**: The seven types of muda (Myers, 2015)*

- TRANSPORT

  Unnecessary movements of products or materials from one location to another, both within the firm and its supply chain. For instance, the transportation of some components from a warehouse to the production line with a pallet. They do not add any value for the customer; rather they consume resources in the form of fuel, personnel, safety compliances and time

- INVENTORY

  Reserves of finished products, raw materials or work-in-progress located at the workbench, in warehouses or outside the factory, plus information storages or customers just waiting to be transformed or utilized. In addition to the cost of maintenance, space occupation, personnel and transportation, they cause another significant problem: they hide many other types of wastes. Figure 1.2 depicts a metaphor usually used to simplify the explanation: many

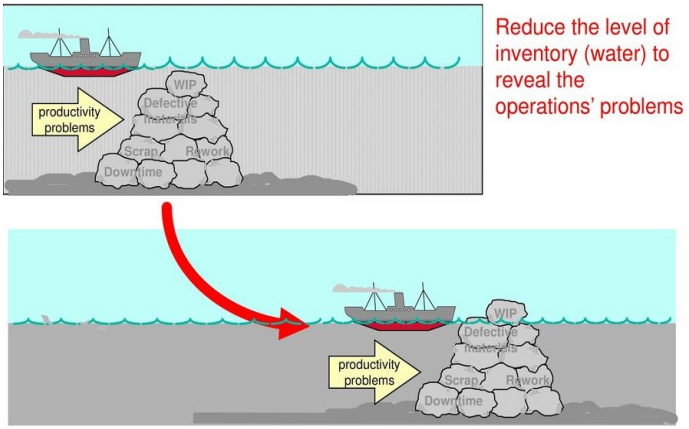

***Figure 1.2**: The inventory metaphor (Slack, Brandon-Jones and Johnston, 2016)*

problems of the operation are shown as rocks lying under the water (representing the inventory) of a river bed. Even if these problems cannot be seen, they slow the progress of the river (which indicates the process flow). Reducing the level of inventories allows management (the ship navigating the river) to uncover them and forces them to work for their elimination

- MOTION

  Unnecessary movements by operators in doing their activities, including those related to information technology. Travelling from one workstation to another, searching for digital documents, bending, stretching or twisting are all examples of motions that can be avoided or reduced to minimize injuries, stress and time wastes, while increasing workers' productivity

- WAITING

  Any inactivity of transformed or transforming resources due to bureaucracy, materials shortages, capacity bottlenecks, machine breakdowns. These all cause delays and disrupt the flow of internal and external processes, knocking down machine and labour efficiency

- OVERPROCESSING

  Any activity that is performed in a longer, more difficult way, due to inappropriate techniques, oversized equipment or incomplete information. This category also includes activities that are repeated too many times or not required by the customer. In each of these cases, time and money are spent without any profitable return, because flow is disrupted and delays are accumulated

- OVERPRODUCTION

  Supplying more or less than what the customer[4] has required, too early or too late with respect to the requested timing or providing the wrong products. This also happens in service firms when they have extra capacity that are not using correctly. Overproduction is the greatest source of *muda*, according to Ohno (1988), as it amplifies or generates many others consequently. It generates inventory and ties up money, it creates shortages because processes are busy making the wrong products, it impairs the ability of the firm of delivering on time and reduces flexibility to respond to customer requirements

[4] Both final and internal ones

- DEFECTS

  Any product, service, material or component that does not meet quality standards. These require rework, which disturbs the process flow; fixing, which is a waste of time, money and people; scraps (when they cannot be repaired), which is, again, a waste of resources. They eventually cause delivery delays, loss of customers and reputation damages

When the TPS was adopted in the Western world, another type of *muda* was recognized and added to the list: the waste of talent. Human potential and creativity is one of the most important asset companies possess, but they often do not harness it enough. For example, because management does not engage frontline employees' knowledge and expertise in their activities of strategy deployment or product development; because operators are given the wrong tools to perform their work, both in terms of equipment and competencies; or because of a poor assignment of tasks, where they cannot utilize their capabilities at their maximum.
Once all these types of waste are perfectly internalized, firms can proceed in the quest for their elimination by applying one by one the five lean principles, first presented by Womack and Jones in their book "Lean thinking" (1996).

1.4 The five lean principles

These five principles are the foundation of the lean management system, with which any firm can prosper by banishing wastes and focusing on what the customer values the most. However, to fully internalize them and be able to apply correctly the lean techniques, keeping in mind what types of waste reside within the firm and its supply chain is not sufficient. It is also necessary to deeply know every aspect of the organization process that is about to be transformed in view of being lean.
The first step to conclude before anything else is taking a particular walk in the company, a *genba* walk. *Genba* is a Japanese word that means "the actual place where value is created". Hence, the management task is to personally visit their organization in search of problems, to identify wastes and understand processes at the operative level. Nevertheless, this is only one part of the lean mantra "Go see, ask why, show respect". In addition, managers must ask fundamental questions to problem owners about their nature and the correspondent best possible solutions. Higher-level executives cannot have all the information and knowledge that comes from the everyday experience of the operators. For this reason, it is important to discuss

with the operators on how the process works, to surface issues and solicit ideas for improvements. This is showing respect to employees: favouring their active participation in the decision making process about selecting what is the best countermeasure. The implementation is then assigned to him/her but the manager has to continuously challenge him/her, asking for the reasoning behind it, for more facts and statistics. This transfers responsibility to lower level employees, empowering them, and makes their contribution valuable, while building mutual trust: the manager respects the operator's knowledge and the latter recognizes that being so closely involved may sometimes cloud his/her judgement. In the Toyota production facility in Georgetown, Kentucky (USA), plant workers have made about 80 thousands improvement suggestions, supported by their team leaders. 99% of them were implemented (Liker, 2004).
Combining a thorough understanding of the internal processes and fostering employees collaboration is the fundamental basis to successfully apply the five lean principles.

1.4.1 Define value

The starting point of the lean system is the identification of what is valuable and useful, to distinguish it from what is waste and only consumes resources without any positive returns. Hence, the hunt for *muda* begins with the definition of value. For whom, you should ask yourselves. For the firm's management? For its shareholders? No, value is only what the final client would be willing to pay for.
Some clarifications about this definition are necessary. Value is generated by the producer through a specific offer of products or services, with particular features and at a certain price, but its existence is ultimately determined by whether it satisfies one or more customer needs better than other competitors. A final client can be internal (another department, for example) or external (for instance, a final customer or a retailer) with respect to the company: anyone who gets benefits, satisfies a desire or an interests, thanks to the producer's offering, in exchange for a specific contribution. Moreover, the choice of using the verb at the conditional is not random. If the customer saw what is inside any factory, for sure he/she would lower his/her willingness to pay: what are the benefits for the customer from the transport of a component from the warehouse to a plant? How does an employee waiting for an approval from his boss create value for the consumer? The customer is currently paying more just to compensate all the wastes that every firm commits along its processes on a daily basis.
After having understood what value is, the next step is to identify and reconfigure it in light of what the customer values the most. Companies have difficulties in this task, as they dislike

radical changes; they are more likely to be comfortable in continuing what they have always done, in the way they are doing it. In addition, the situation gets more complicated due to the incapacity of many clients to define precisely their true needs. They make the usual requests of higher delivery speed, better quality and so on, rather than trying to understand what they truly need. Another huge problem is that products are often created with the contribution of many entities within large value chains. Therefore, each of them identifies value in a different manner, because each player is focused firstly on its own interests. Everyone offers a partial product and looks at its own operative efficiency, rather than at the whole product process in the eyes of the customer.

A potential solution to disentangle these issues is a collaboration between the firm and its clients, being them internal or external. Talking about their expectations, their needs together, so that the product can be redefined to meet them while maintaining a certain level of profitability. Some questions require an answer with respect to the firm's activities, in this case: is the current process necessary for the customer? Is it better at solving his/her needs than that of competitors? Would the customer notice if the activity was deleted or changed? Would he/she be happier and willing to pay more for a greater level of this process? If most of the answers to these questions are positive, it means the activity is actually relevant for the customer satisfaction.

The final element of the definition of value is firm's profits. In contrast with the traditional view, the lean systems states that they cannot be decided by tweaking prices. Firms are price takers (with the exception of monopolies); they can only act on costs since price is determined by the market, by the willingness to pay of customers. For this reason, lean organizations redirect their efforts in the elimination of every waste. This allows them to set a target cost level lower than that of competitors and reap higher returns, even if price has remained the same. Furthermore, they are able to free up money, people and time and redeploy these resources to improve the quality of the product or increasing the production volumes, which eventually turns into more profits.

In essence, the lean system is highly customer and people-centric; but let us not forget that a happy customer is ultimately good for any firm's shareholder, manager or employee. As Jeff Bezos, Amazon's CEO, said in a letter to the shareholders in 1997, working hard today means that customers will acquire more in the future. Bringing happiness to clients generates long-term value also for the firm stakeholders, so focusing on the former does not mean that the latter are neglected, not at all. Therefore, it is important to create a solid value creation framework, which considers all players involved in the game. The value identification starts from the

customers, but then the company has to develop a sound value proposition that takes into account all stakeholders needs, aligning every player's objectives in the value chain towards them. Maintaining the promises made in the value delivery and adapting it to the sector's characteristics will guarantee a bright future for the firm.

1.4.2 Map the value stream

Value has now been characterized. The next step is to retrace, map and analyse every action and activity required to deliver that kind of value to the final customer. Differently from the strategic value chain first explained by Michael Porter in 1985, lean management focuses on end-to-end processes rather than on departments' strategies, including all the activities from the collecting of raw materials to the delivery of the final item. Moreover, the point of view is that of the final client, instead of how the firm can make profits at the expenses of any other actor. These concepts are embedded in what lean literature calls value streams, processes that follow a given product or product family[5] along its entire flow from the beginning to the end.

Every business, even service companies, have to deal with three types of process flows within these value streams: problem solving, regarding product design, detailed plan and launch to production; information, referring to the handling of all the data, feedback, orders coming from customers; operative, which includes all the tangible activities that transform inputs into outputs. Each of them is characterized by five components, usually remembered with the acronym 4M+E: materials, (raw materials, semifinished products, components), men (managers, operators), methods (standard operating procedures, rules), machines (tools, equipment, machinery) plus environment (organizational culture, industry characteristics). Other classifications add more "M"s, such as money, marketing or measurements, and they call environment as Mother Nature. Each organization can choose the one that better fits for its needs, but, as a rule of thumb, the less complicated they are the better.

The lean tool utilized to analyse processes and their components in detail is the value-stream mapping (Rother, Shook, 2003). This technique is extremely important, as it helps to visualize a description of every step of the process and capture the logics and mechanisms that regulate it, so that everyone can easily understand. The advantages are many. It shows the connections between the various phases; it allows to link operative and information flows; it helps discovering wastes and the critical points of the operation; it measures certain important

[5] A group of products that passes through similar processing steps and over common equipment

indicators (such as the lead time, the time between the receipt of a customer's order and its delivery).

In practice, the first step is drawing a current-state map for a specific product or family of products, by gathering information on the shop floor about each and every activity within the corresponding value stream. This map is always composed of three parts: the operative flow at the centre, the information flow at the top, and a timeline at the bottom, which shows the working and waiting timings. The drawing makes use of several intuitive icons or symbols, which may indicate material or information flows, process phases, operators, areas needing improvement and so on. Figure 1.3 provides some examples.

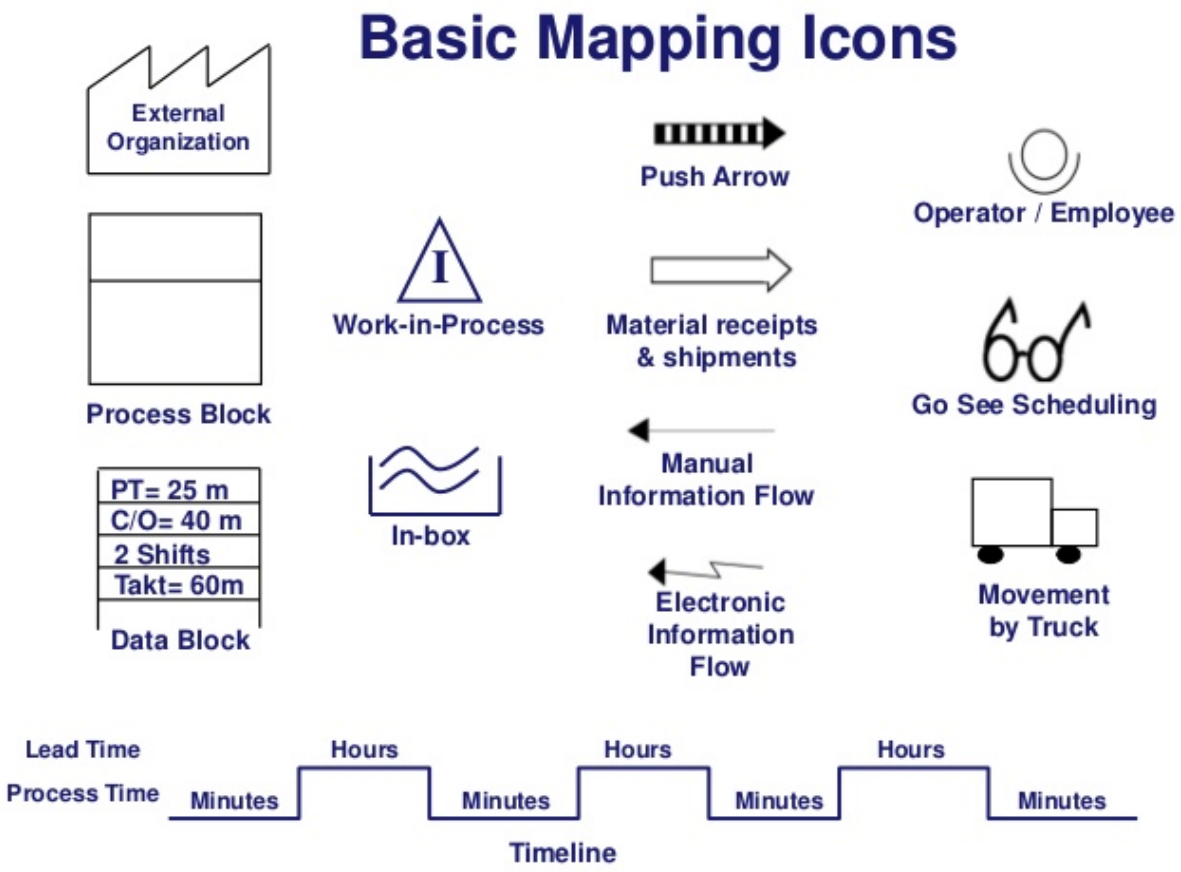

***Figure 1.3**: Basic mapping icons. Available at: https://www.slideshare.net/KarenMartinGroup/value-stream-mapping-in-office-service-setttings/40-Basic_Mapping_IconsExternalOrganizationPush_ArrowOperator_EmployeeIWorkinProcessMaterial*

The second step is about drawing a future state map, an ideal situation that represents the same value stream optimized to reduce problems and eliminate wastes. This should be prepared along with the previous one, since future state ideas are often conceived during its elaboration. The final step is developing and actively following an action plan, which illustrates the activities and modifications to be implemented in order to reach the ideal future state. The process does

not stop here; the cycle has to be adopted repeatedly to continuously improve the value stream flow.

So, how to create a streamlined future state map? First by investigating every phase of the value stream in search of any kind of *muda* and then applying the third and fourth lean principle, covered in the next sections.

Let us focus, for now, on the first step, that is classifying activities within a process into three main categories: value added, which create value perceived by the customer and for what he/she is willing to pay for; non-value added of type 1, that do not create value, but are necessary for the current process because of regulatory requirements, technical or financial constraints; non-value added of type 2, which do not create value and only generate waste. The first ones are obviously those to keep and improve, but usually represent only 10% of the total (Liker, 2004). The second ones are dealt with applying flow and pull techniques, explained in the next paragraphs, as mentioned before. The last ones must be removed immediately and are the focus of the second principle: mapping value goes hand-in-hand with the elimination of these clearly unnecessary activities. However, banning them is not sufficient; their root cause must be identified and eliminated. The so-called 5Whys analysis comes to help. It can be applied in this situation as well as when facing any problem the firm encounters. Ask yourself why as many times as you need to find the root cause that is generating the *muda*. Five is a symbolic number to which Ohno (1988) referred, saying "by repeating why five times, the nature of the problem as well as its solution becomes clear". There can be more than one, so make sure to identify them all. Once they are pinpointed, eliminate them using corrective actions, one by one, starting from those that have the greatest relative impact on the problem. If this *muda* analysis is not thoroughly followed, it will eventually represent itself again, causing further losses of money and time.

This whole activity, though, is not limited to the internal operations of a single firm. Many players constitute value streams, since it would require an extreme level of vertical integration to manage all the end-to-end process of a product. The mapping, eventually, has to be expanded beyond the borders of the single organization and embrace every firm in the value stream that is contributing to value creation, from the supplier of raw materials to the player that delivers the product to the final customer. These actors need to work together, applying all the five lean principles and being transparent about their activities regarding the value stream. One company alone has only so much to improve, if it is not followed by others' efforts.

1.4.3 Create flow

The next phase involves making value and value streams to flow. Eliminating the root causes of waste sources is a big jump in this direction, but there are still some cumbersome obstacles to remove before we can really say value is flowing end-to-end without interruptions.

The third principle has two main aspects, an organizational and an operational one. Usually, the former comes before the other in a lean transformation, so it will be treated right away.

Many firms are organized in units that represent functions or departments (marketing, production, administration and so on) with specific boundaries of responsibilities, process logics and people's mindset based on common competences or activities. These inevitably divide the company, they break its unity, as each will eventually care more about its interests and act accordingly, harming the overall well-being of the firm. The advantages of this organizational structure no longer hold. It was meant for markets characterized by low product variety and high volumes because economies of scale and specialization could bring about excellent results.

In addition, customers are interested at the output of the firm's processes and most of them cross the organization horizontally, encountering several different functions. Conflicts between them only slow or worsen the processes performance, to the detriment of consumers. Therefore, it is more appropriate to allocate resources and responsibilities to each value streams, to which is also assigned a manager with the precise task of taking every action or decision needed to maintain continuous flow (Furlan, 2018). The resulting organizational form, despite being unconventional, will be more integrated and guarantee better outcomes in terms of quality, costs and time.

The next step for creating flow requires to zoom in, within the processes, to change the traditional batch and queue approach. In the mass production system efficiency was the main goal for the whole organization. This meant machines and people were pushed to work at the maximum capacity at high speed and volumes, so that marginal costs were reduced to a minimum. Similar machines and similarly skilled people were grouped in departments to squeeze the highest productivity possible in each professional specialty. The result were sequenced large batches of products, separated by significant amounts of inventories that usually idled, waiting to be moved to the next department.

Lean management, instead, aims at achieving a one-piece flow (make one, move one), capable of answering faster the various and unstable needs of today's customers. In order to reduce batch quantities to one, a radical transformation of the production line is required. First thing to take care of is the layout reorganization. An industrial layout is the machinery, equipment and

services arrangement that allows the transformation of raw materials or derivatives into finished products (Pareschi, 2007). Only a line or a cell layout, in which transformed resources follow a precise sequence of activities that satisfy all their immediate processing needs, can sustain continuous and predictable flow. Here, machines are located near to each other, usually in a U-shape, to reduce transport and motion wastes (Figure 1.4). Each process step time is balanced to eliminate internal inventories accumulation and set cycle time near the *takt time*[6]. One product at a time is treated, which drastically reduces production lead time and, as a consequence, the time the customer has to wait for his order to be processed. All those who contribute to a common activity are in sight of each other, so that they can oversee the process and help each other in case of need.

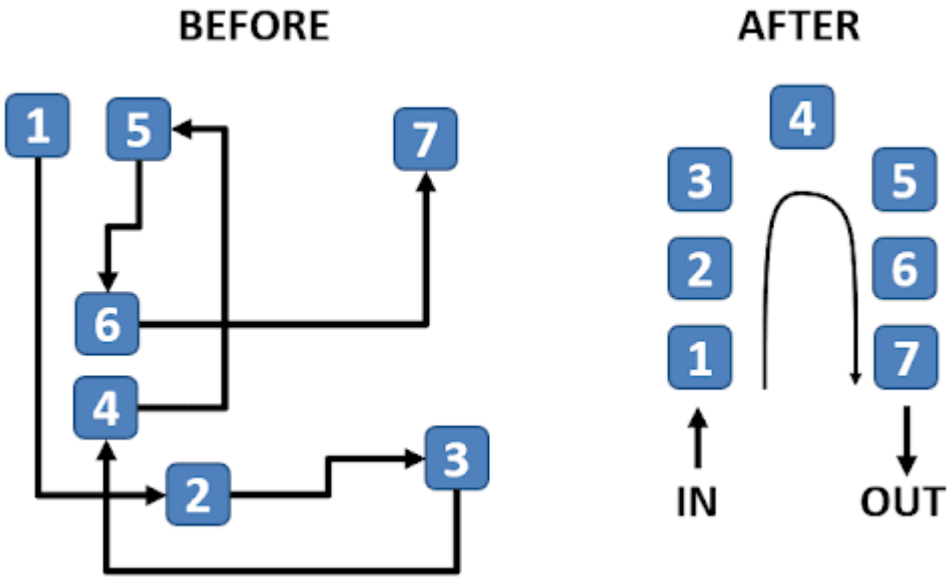

***Figure 1.4**: Transformation from a functional to a cell layout. Available at: http://www.leansixsigmadefinition.com/glossary/cellular-manufacturing/*

Inside this layout, other changes must be applied. First, the huge, cumbersome machines of the mass production are substituted with small-scale technologies. It is true that some speed and efficiency losses occur (duplication of machines, less powerful engines), but the advantages gained in terms of process stability (flexibility in movements and investment decisions is increased) and cost reduction (inventories are eliminated, maintenance is easier) are overwhelming.

[6] Cycle time is the time span between the exit of one product from the production line and the next one, whereas *takt time* is the required production rhythm to meet customers demand. The goal is to get them as close as possible, in order to synchronize supply with demand

Second, changeover time must be reduced at a minimum, otherwise the one-piece flow is not sustainable. The SMED (Single Minute Exchange of Die) lean technique aims at reducing them at a time below ten minutes. The setup (the time between the last adequate product of the previous batch and the first adequate product of the current batch minus its processing time) are minimized by identifying what are the activities to be performed necessarily when the machine is down, for example because of technical or safety reasons. Some of them are then modified or prepared in such a way that they can be executed when the machine is working, decreasing the non-productive time. Finally, all the activities are analysed and tested to be improved or even eliminated.

Lastly, production has to be levelled in terms of quantity and type of products over a fixed period of time. Variability in the product mix is one of the biggest causes of flow disruption and desynchronization (Slack, Brandon-Jones and Johnston, 2016). The goal is to be able to produce and deliver every part at least once per day, creating a precise sequence of volumes and mix. This is the process of levelled scheduling or *heijunka* in Japanese. It enables production to efficiently meet customer requests, faster and in the order in which they are received, while avoiding batching and inventory accumulation. Furthermore, the regularity of the production rhythm simplifies planning and control activities because each stage has a clear program to which actual performances can be compared. The sequence, though, must be reviewed periodically according to changes in customer orders (Marchwinski, 2014).

Successfully managing all these transformation activities will create a smooth flow, with positive effects on customer satisfaction and making the company more competitive at the same time.

1.4.4 Use a pull approach

A perfectly flowing process is almost useless if it is not linked to the demand. Its highly variable and ever changing nature requires firms to adopt a new approach, pull, with respect to that of the mass production, push. What are the main differences? For starters, a mass producer aims at accumulating inventories to be always ready to push products towards customers, according to a previously determined complex forecast. A lean producer, instead, keeps inventories at a minimum and has a very easy forecast system, if any at all, because products are pulled by clients' requests. A mass producer efficiently optimizes every stage of the process, but none of them is connected between each other, hence they work whenever they can (even if it not necessary) at a different pace. In a lean firm, every upstream activity is strictly linked to its

downstream one and starts producing only if the latter has triggered the operation. A push system has very long lead times that make customers wait more than they are willing to accept. A pull system shortens them to get as closer as possible to an exact and instantaneous delivery, which is highly valued by any customer. Finally, while a mass producer plans materials and human resources in advance, a lean producer determines their number based on the actual *takt time*. In its very essence, the pull approach says that supply has to be subordinated to the real demand.

Practically adopting a perfect pull logic is very difficult (Rother, Shook, 2003). There can be several reasons: some processes are designed to operate at very fast or very slow cycle times and need to changeover many times to serve multiple product families; some are located far away from the plant and producing one piece at a time becomes impracticable; others can be too unreliable to directly couple them to upstream activities without increasing lead time. In these cases, companies should introduce a supermarket pull system, in which stages are still connected to each other, but not in a continuous flow because they still operate producing batches. The idea comes from real supermarkets, in which individual items are replenished only when their shelves are close to being empty, so, in the end, refill is initiated by consumption. In a firm, supermarkets basically are a controlled inventory, located between the two activities, which regulates the upstream supply according to the actual usage and requirements expressed by the downstream customer, without recurring to unreliable forecasts. The upper stage produces a small batch and places it in the supermarket. The material handler of the lower stage withdraws what he/she needs when required and the supermarket is replenished only when the batch is finished or when a certain quantity is left. Some firms also use safety stocks, a reserve always ready as a hedge against unexpected problems (such as downtimes), or buffer stocks, that are small extra quantities of product kept for protection against sudden fluctuations in customer orders. These should be only temporary solutions until the root cause of the actual problem is identified and solved.

Supermarkets are functioning thanks to the use of particular cards, *kanban* in Japanese. They are paper cards containing essential information about the product, for example the supplier, the quantity requested, part name and identification number, the due date and so on (Figure 1.5). There are two main types of *kanban*: a withdrawal *kanban* is basically an instruction list for the downstream customer about what and how many parts to withdraw from the

Part Description				Part Number	
Smoke-shifter, left handed.				14613	
Qty	20	**Lead Time**	1 week	**Order Date**	9/3
Supplier	Acme Smoke-Shifter, LLC			**Due Date**	9/10
Planner	John R.		Card **1** of **2**		
			Location	Rack 1B3	

Figure 1.5*: An example of a paper kanban. Available at: https://www.velaction.com/kanban-card/*

supermarket; this triggers a production *kanban* that signals to the upstream stage to produce what has just been taken. Usually, they are made of paper, but some companies are more creative and make use of coloured ping-pong balls or solid plastic markers (Slack, Brandon-Jones and Johnston, 2016). Nowadays, though, they are mostly electronic because they do not waste materials and they are transferred much easier and faster. Still, it is better to implement them in that format only when the technique is well known and understood. *Kanbans* can also be skid resistant lines or tapes, usually of bright colours to attract attention, placed on the floor around pallets or piles of products. The objective is the same: when the space inside the lines is empty it means that the product indicated in the label has been withdrawn and is needed to be produced again.

If needed, *kanbans* can also be used in the office to save money and help avoid shortages of supply. For example, cards can signal when a new ream of paper is required or when the soft drinks distributor is running out of Coca-Cola. Benefits may even go beyond this, spurring employees to find new ways of creating flow in their work.

Anyway, all *kanbans* represent a form of inventory and, as such, they must be reduced over time and eventually eliminated in the long term, with the aim of adopting a pure continuous flow pulled by the customer (Liker, 2004).

1.4.5 Pursue perfection

The last principle, one of the most important, fosters a reflection on the dichotomy doing lean vs being lean. If you have correctly followed the first four lean rules, your organization has gone far and current performances will surely demonstrate that. You have successfully implemented a *kaikaku*, where *kai*, in Japanese, means change while *kaku* means radical: processes drastically improved in a short period of time, thanks to organizational and technological improvements, and created a clear detachment from the past. However, in the case in which the transformation stops here, it is likely that, over time, the organization will revert to its previous routines and mentality. It is just what human nature intrinsically is; it prefers to stick to old habits and avoid uncertainty or difficulties. This is what doing lean means. It is like going to the gym for intense workouts for a month and then never do it again; the obtained results are significant, but ephemeral. Being lean, instead, is analogous to being an athlete: practising over and over again the same exercises until you have mastered them close to perfection and they have become a daily routine. What is required is to embrace the concept of *kaizen* (here *zen* means good), embedded in this last principle and in the lean culture. It

explains that firms should strive for perfection, even though complete elimination of waste, flawless value streams and products that meet entirely the customers' desires (including price equal to 0) are only ideals. In fact, there is no "one best way", as Frederick Taylor believed in 1911, and benchmarking against the recognised best firm in the industry is no longer a viable alternative. In trying to reach perfection, organizations are then pushed to continuously improve, one small step at a time, knowing there is no true end in this process, but more can always be achieved.

Luckily, a solid base where to start exists: standard work. A standard is a defined, formalized, shared and measurable reference that defines and organizes an operation or a process to ensure its repeatability and limit its variability. In practice, it documents the current best practises for workers, equipment and processes, by measuring *takt* and cycle time, recording all the necessary steps, identifying the tools, setting the work sequence, minimizing waste and variations.

After every lean *kaikaku*, new standards are determined, so that the positive changes made can be assimilated and maintained in the future. These provide the fundamental basis for future improvements; if there is no previous measurement, how can it be possible to assess the implemented changes? They allow operations to stabilize and to better detect deviations from the predetermined set of activities required. Moreover, workforce is encouraged to participate and give its contribution to the design and modification phases. There is no coercion like in the Taylorism theory, rather an environment of innovation and empowerment (Liker, 2004).

Once standards are established, lean firms should begin *kaizen* transformations by applying the SPDCA cycle, a scientific method dating back to 1939 and then further developed by many other authors (Moen, Norman, 2010)[7]:

- S for SCAN

  Analyse in detail the current state of the operation and its surrounding context, physically going to the *genba*. Search for any waste to eliminate or any opportunity for improvement. Do not underestimate this first step; without a clear understanding of the starting situation, no good strategy can be elaborated

[7] In 1950, William E. Deming, an American engineer, first invented a four-step cycle, the Deming wheel, inspired by the work of Clarence I. Lewis, an American philosopher. It was a method for quality control. Then, several Japanese authors revised his idea to create the famous PDCA cycle for management purposes. Thomas L. Jackson, an American economist, finally added the Scan phase a couple of decades later

- P for PLAN

  Identify the root cause of the problem or the driver for the opportunity. Find potential solutions and define the essential indicators upon which the improvement will be verified. Make cost/benefits evaluations and gather opinions from different actors. This phase is often neglected to skip right to the next one because it is considered not important and a waste of time. On the contrary, it is the key for success

- D for DO

  Execute the planned activities after answering to the so-called 5W-2H questions (Who, What, Where, When, Why, How and How much time). Experiment with various alternatives to understand which one is the best according to the current needs of the firm and its customers

- C for CHECK

  Record the activities and verify their results. Were they in line with the defined plan? Were objectives achieved? Which was the solution that has proven to be best? Deming later substituted this letter in S, for Study (Moen, Norman, 2010), to highlight the importance of examining the performances in light of a learning process to avoid future mistakes

- A for ACT

  Choose the best solution and abandon the others. Standardize it so that it can be precisely repeated and apply the standard to any other process that may benefit from it. This is when the improvement is actually consolidated and sustained

The cycle is now completed, but, periodically, standards must be reviewed with the aim of restarting the process to continuously improve (Figure 1.6). This method is usually applied to detailed work processes of improvement but true learning organization use it at all levels of the company and even across firms.

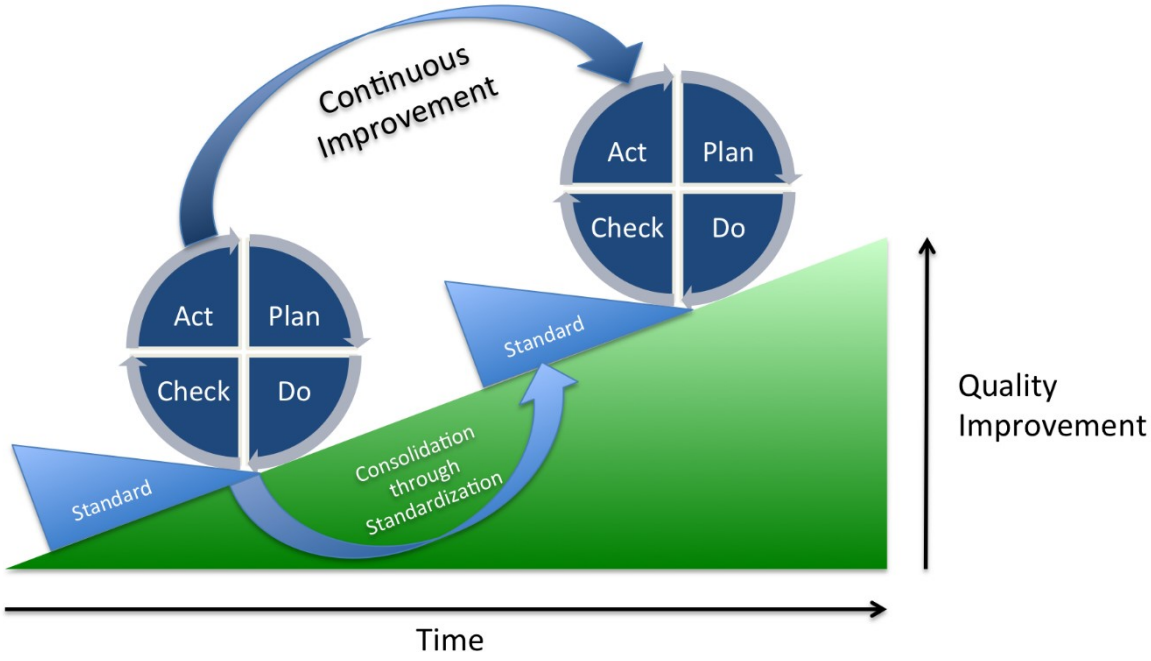

***Figure 1.6**: The continuous improvement process. Available at: https://en.wikipedia.org/wiki/PDCA*

The success of any change process, however, highly relies on the involvement of everybody. Individuals at every hierarchical level must support change: top management has to provide a clear vision and lead by example, showing commitment and motivating their subordinates; employees must be empowered, given a chance to participate and contribute with their own abilities and knowledge, by granting them autonomy and responsibilities. Their engagement is determined by internal and external motivations (Furlan, 2018). The organization must be able to satisfy their need of belonging by promoting shared values and creating teams governed by good leaders and solid trust. The need of self-realization is important too. Economic incentives are insufficient and, in some case, even deleterious; people also need to be aligned with their professional role, in a way that their intrinsic characteristics, their talent match the responsibilities and task assigned. An internally motivated person will be much more productive and willing to put more effort in his/her work.

This internal engagement, then, must be guided, otherwise, without a clear external objective, the commitment will be devoid of meaning. A lean system defines the ultimate goal, the firm's desired outcome towards which each component of the organization should dedicate his/her effort: the so-called True North. People are instructed on the beliefs of the company, they are inspired by a sense of belonging to something greater and challenged to continuously improve themselves. Articulated coaching processes, creation of career opportunities and fair performance evaluations all contribute to the achievement of the True North.

People are what ultimately makes the difference in pursuing perfection.

1.5 Lean outside the production function

So far, we mainly talked about production processes within manufacturing firms. The justification is that usually the *genba* is the production process and its facilities; however, lean principles can and should be applied everywhere. Immediately following is the transformation of the various offices, starting from the orders management. Here, traditional Material Requirements Planning systems are substituted or reduced in their complexity and use. Indeed, an MRP calculates future demand based on customer orders and demand predictions. This methodology does not meet the JIT philosophy, since it is weak to any disruption and favours the accumulation of inventories in large warehouses. Delivery lead time are drastically shortened by increasing the number of orders, along with diminishing the batch quantities. Visual management tools are also useful, such as large boards near the production process on which *takt time*, orders and current production schedule are visible and controllable for everyone.

Next in line is the sales department, rarely connected to what happens in the *genba*. Traditional salespeople are focused on making a sale or finding new prospects as quickly as possible, so that they can move to the next one. Customers' needs and problems are overlooked in favour of the firm's objective of making money. To realign the sales process with what clients value, identify what the customer really wants, what are the steps in the acquisition journey that are the most critical in his/her point of view. Then, map the value flow and make it visible and measurable, while avoiding poor evaluation metrics for salespeople based on the number of new prospects gained. Also, train them to assist the customer in each of the customer touchpoints in a standardized manner, guiding them in the satisfaction of their implicit and explicit needs (Furlan, 2018). Sales must not rely on the individual exceptional capabilities, but on a stable and repeatable process: science of selling should prevail over its art. Finally, connect them to what the production can actually sustain, to improve the firm's dependability, rather than accepting orders that cannot be completed on time.

The last step is usually rethinking the product development process. Currently, mass producers have very inefficient development processes because they involve conflicting contributions of various departments. The project is designed with the specifics dictated by the commercial function, but it is then object of repeated modifications and backflows since the other functions have different requirements and cost structures to satisfy. This causes delays, flow disruption and increases time to market, with a serious possibility of selling products when they are not requested anymore. Even if that is not the case, budgets are often exceeded and quality problems

are more likely to be detected late, causing customers complaints or even litigations and losses of clients.

A lean design has the objective of increasing quality while reducing costs and time to market. The development process must consider what customers really want, through a deep understanding of industry trends and characteristics. Functionalities and specifics are set according to an analysis of their relative importance in satisfying clients desires; some alternatives are taken into account and tested to verify which the best one is. Afterwards, these pieces of information are integrated with the actual capacity of the firm to satisfy them, as well as the suppliers' skills and limits, and the product innovation is synchronized with the demand rhythm. The process is now managed in a simultaneous way, in which every function collaborates and coordinates its effort with that of the others, sometimes even involving final customers to have important feedbacks right away. Costs are reduced using design standards, such as modularized components or error proof assembly. In addition, visual management tools like the Gantt are used to plan the sequence and timing of the activities in a transparent and clear manner. The overall result is a wider variety of quality products, replaced more frequently and at a lower cost to follow demand changes (Womack, Jones and Roos, 1991).

Many problems in the value stream, unfortunately, are out of control of the single organization. A significant part of the total costs of a lean firm is due to its suppliers and distributors. The lean transformation goes beyond the company and embraces all members of the supply chain to reach every step of the process. However, many suppliers are reluctant to change, especially if they do not understand it. That is why a lean firm has the duty to intervene to help. A group of people is usually formed (called *kaizen* team), whose members are employees from various backgrounds that have been recognized for their efforts. Part of their job is to reduce the number of suppliers and distributors, eliminating those that are not willing to listen and those who provided services or components that the firm is now doing in house because of all the resources freed up by the use of lean techniques. The double-sourcing approach, according to which parts, materials and components are always supplied by two firms (one is too unreliable, while three or more is too costly), further narrows their number down, sometimes arriving at 20% of the previous one. Another important task is building strong and long-lasting relationships with those remaining and teaching them the lean message to foster the transformation in their facilities and mindsets too. Long-term relationships build trust and allow players to look at each other as partners rather than adversaries. Costs are jointly analysed and process are transparently shared so that everyone's needs are clear and may be accommodated for.

The burden of teaching will be compensated by the elimination of quality checks on received components, because suppliers are now working better, the stability of deliveries, both in and out of the firm, the sharing of the obtained savings and, sometimes, special services to return the favour. When the direct suppliers and distributors are instructed, the *kaizen* team will encourage them to do the same with their own until the whole value stream is fully lean.

The lean system is not even limited to the manufacturing sector, nor to the shop floor. Still, services are very different. They are usually intangible; they are a series of activities rather than physical products; they are produced and consumed simultaneously to some extent; customers often participate in the production process, to some extent, increasing the level of uncertainty. For these reasons, some lean tools cannot be transferred to services and others need some adjustments, but the underlying basic concepts should be applied. For example, it would not make sense for a lawyer to sit at his/her desk waiting for a material handler to deliver a *kanban* asking for the next legal brief. However, analysing the process from the customer point of view and drawing a future state map could still be very helpful to improve it.

Moreover, service firms deal with two different types of demand: value demand refers to the customer regular orders of the company's product, *lato sensu*; failure demand comes from the inability of the firm to perform its duties or to do them as the customer expects. The second is the highest form of waste for a service firm and, as such, must be eliminated. To do this, the root cause of the problem must be identified and solved with dedicated actions via 5Whys analysis. Again, think about standardization. In this sector, variability is much higher, as each customer may have more or less different requests. Hence, standard work is often deleterious because clients can directly see the waste and the missing problem solving capacity if the operating procedure is inefficient in tackling the variance. Rather, it is better to train employees to answer to the customer orders with the highest frequency and pull the expertise of greater level managers only when needed. The concept of one-piece-flow also applies in this situation: workers should satisfy each order as they enter the system and move on to the next one only afterwards; flow is achieved by thoroughly analysing the customer journey end-to-end, continuously improving all the critical touchpoints (Seddon, Donovan and Zokaei, 2009).

Cynthia K. Swank (2003) provides a good empirical example of a lean system application on an American insurance company, Jefferson Pilot Financial (JFP). Linked processes were put near one another to create cells, for example employees who worked the application and employees who sorted them out were located in the same floor. Standard operating procedures were established and loop-backs were eliminated by giving workers clear guidelines on how to handle applications. Workloads were balanced and redistributed among the employees teams based on a sequential allocation, rather than alphabetical, so that no team remained idle. Large

white boards and transparent performance metrics were used to push everyone in the organization towards improvement. As a result, the company halved the average time from receipt of an application to issuance of a policy, reduced labour costs by 26% and trimmed the rate of reissues due to errors by 40%. These outcomes contributed to a remarkable 60% increase in new annualized life premiums in the company's core individual-life-insurance business in just two years. Similar results were recorded in other departments as the company extended the new system across the whole organization.

Healthcare is another important industry in which lean can be implemented with great benefits for the society. Womack (2013) cites the case of the American ThedaCare Hospitals in Appleton (Wisconsin, USA). The management first set a clear True North of providing good treatments to patients while guaranteeing a satisfying working experience for doctors and all their supporting staff (nurses, techs and so on). They adopted a PDSA approach to problem solving. They identified and improved the entire patient journey by product families of diagnosis and treatment rather than relying on the traditional functional structure of hospital wards. Finally, standard works for many activities were implemented. The organization went under a great transformation and shared all its benefits with its customers.

Several studies and empirical results have demonstrated that the lean system knows no boundaries for its application, geographical nor cultural or political, and does not distinguish between small of big enterprises. The movement is growing year by year and even if there is still a lot to do in some key sectors (such as education and government), for many others incredible results have been achieved so far.

2. THE ROOT OF CONTINUOUS IMPROVEMENT

The main concepts of the lean system come from the Toyota Production System and are often summarized with the TPS "House" (Figure 2.1). There are different versions of this framework, but the core remains the same, as well as the shape. The house represents a structured system that conveys the idea of stability and strength, in which all its components (the roof, the pillars and the foundation) are interdependent and integrated between each other (Liker, Morgan, 2006).

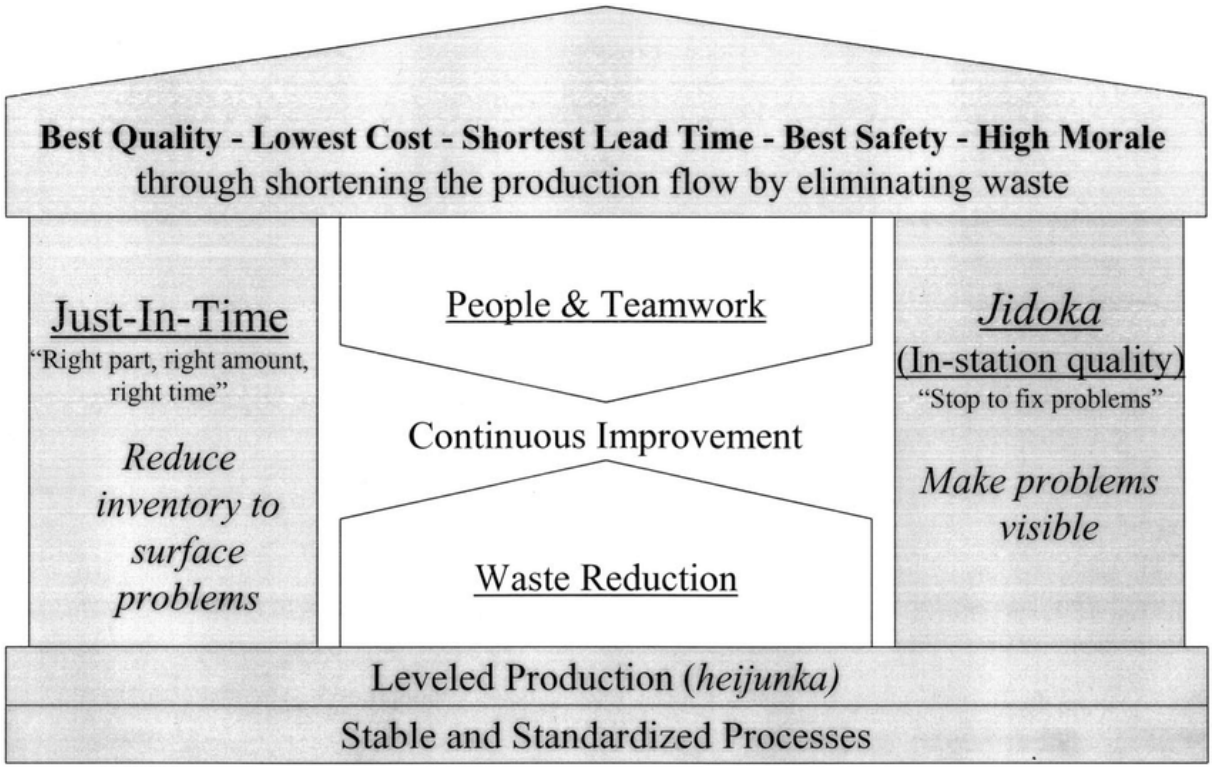

***Figure 2.1**: The Toyota Production System House (Liker, Morgan, 2006)*

The picture shows the ultimate goal of lean organizations at the top: maximize the value delivered to customers to satisfy their needs, which means providing highest quality products at the lowest cost possible with the shortest lead time and . This strategy can be achieved by relying on Just In Time and *jidoka* methodologies, the two columns of the house that sustain the roof. Implementing one-piece-flow, keeping inventory at a minimum and stopping production whenever an anomaly is detected causes a great instability, while increasing the sense of urgency. A balanced equilibrium is reached when *heijunka*, standardized work and stable procedures are put in place. These form the solid foundation on which the entire house can be safely built.

At its very centre, there is a fundamental component, continuous improvement, which is the everyday goal of the whole transformation process: keep finding new solutions to improve, as there is no one best way. This effort is sustained by a constant identification and elimination of all types of waste, but, most importantly, by people, the element that binds everything together and drives any growth or improvement strategy. Lean is built around people, advocates a "respect for humans" system and implements the "involvement of everyone" principle (Slack, Brandon-Jones and Johnston, 2016). Resources are spent to guarantee safety and environmental standards and provide good quality of working life, including equal treatment and consistent pay structures. These foster discipline and motivate employees. Moreover, delegating responsibilities, giving decisional autonomy and promoting personnel growth and training through job rotation allow employees to be creative and flexible, capable of adapting to different situations.

Lean organizations strive to develop and grow excellent people that believe in what they do, embrace the lean culture and are willing to constantly challenge themselves to improve. Higher-level managers and supervisors are expected to exert positive leadership by helping their subordinates, communicating a clear vision and showing by example. Shop-floor workers are expected to be good problem solvers, well prepared in their job and capable of identifying and resolving potential deviations from standards. Everyone should be formed by the organization values, engaged in their activities and should strive for continuous improvement. These are fundamental ingredients for any successful initiative. As Turnbull (1986, p. 203) argues "the organization and management of employees, together with their attitudes, are perhaps the most important (and certainly the most idiosyncratic) resource on which productivity and competitive advantage ultimately depend".

This chapter draws on the consideration that the lean system cannot survive without proactive individuals and problem solvers (Galeazzo, Furlan and Vinelli, 2017). JIT and *jidoka* surface problems on an ongoing basis and developing the dynamic capability of continuous improvement is essential to sustain a competitive advantage in the long term. Problem solving, especially within teamwork, is key to create an organizational infrastructure that supports continuous improvement and solves emerging issues at their root cause, which holds true for every firm, even non-lean ones.

Because the endless journey of improvement of products and processes highly relies on employees' proactive behaviours, the first part of the chapter provides some theoretical background on what it means to be proactive. Current relevant literature will be explored to explain what potential drivers of this type of behaviour are and to focus on a factor that has not

been studied sufficiently: shared mental models within teams. In the remainder of this section, a theoretical model is developed, arguing that shared mental models have a direct effect on performances, in particular on those of improvement routines, and an indirect effect, as they foster shop floor employees' proactive behaviours.

2.1 Proactivity

Organizations evolving towards more and more decentralized structures, increasing pressure for constant innovation to stay competitive and career models that are characterized by dynamism and self-direction, all require employees to take on a more proactive role in their approach to work (Parker, Williams and Turner, 2006).

The concept of proactivity derives from a body of organizational behaviour and applied psychology literature. Nonetheless, a clear and unique definition does not exist, as proactive behaviour[8] has been conceptualized and measured in many different ways, for example at the individual, team or organizational level.

According to Parker and Collins (2010), there are two common elements of individuals' proactivity. The first is the element of anticipation, involving acting in advance to anticipate future situations, such as problems, opportunities or needs. The second refers to taking control and causing change, which means controlling a situation and causing something to happen, rather than passively waiting to respond after it has already occurred. Self-starting activities of enacting changes or improvements and personal initiatives to identify and solve problems are essential components of both elements. In synthesis, employees are asked to take an active role: they should actively seek information instead of waiting to receive them; they should challenge the status quo rather than passively accepting it; they should work to create favourable future conditions without the necessary input of an external instruction to do so, going beyond normal job requirements.

The authors identify three main distinct categories of proactive behaviour based on the broad target of impact. Proactive work behaviour is directed at changing the internal organization environment and, according to Parker et al. (2006), two core dimensions are identified. Proactive problem solving (PPS) means taking self-initiated and future-oriented actions to improve the current situation or oneself, to prevent the recurrence of problems in the long term

[8] In this paper, proactivity and proactive behaviour are used interchangeably

or to try to solve them in an unusual and nonstandard way with respect to the relative context and environment. An example from lean is the systematic use of the 5Whys analysis, which allows to examine in depth the issue to eliminate the root causes.

Proactive idea implementation (PII) refers to taking charge of an improvement activity about procedures, technologies, techniques in the workplace and/or product ideas. This can be done by personally taking charge of the initiative, being directly involved in its implementation or voicing it to others, even if not everyone agrees. Proactive work behaviour will be the focus of the present work.

Proactive strategic behaviour is about changing the organization's fit with the external environment. It includes issue selling and strategic scanning. The former influences the formation of the organization's strategies by adopting behaviours that aim at making key leaders or figures know about particular events, trends or phenomena, which may have important implications on performance. The latter refers to actively scanning the external environment in search for potential opportunities or threats to elaborate how the organization might answer them.

Proactive person-environment fit behaviour means changing the individual's fit with the organization environment, such as the compatibility of the person's abilities with his/her job or the alignment of his/her beliefs with the organization's values. For example, feedback seeking by directly asking to peers or supervisors and by actively monitoring how and what leaders reward can give employees a better evaluation of their performances, so that they can improve and better adapt to work requirements. Otherwise, when workers negotiate with others about task assignments and role expectations, they are trying to create a better fit with their skills and abilities. Finally, individuals can engage in career initiatives (like skill development, consultation or networking) to actively attempt to promote their careers.

Organizational behaviour and applied psychology literature has focused also on the antecedents of individuals' proactivity, identifying several relevant factors. Crant (2000) groups them into two main categories: individual differences and contextual factors. The former includes proactive personality and personal initiative, which are connected to the individual's predisposition and tendency to identify opportunities, show initiative, take action, and persevere to bring about change; role breadth self-efficacy, which is the self-judgement on the capability of performing a particular task that extends beyond prescribed technical requirements; and taking charge, a behavioural tendency to make constructive efforts aimed at changing the work environment for the better. All of these capture the propensity of the person to engage in proactive behaviours and display self-starting initiatives in an array of different working

situations; however, empirical research is currently insufficient in determining the relative utility of these factors. The second category includes situational cues, organizational culture and norms (that provide diagnostic criteria against which individuals interpret and evaluate their own behaviours and others'), the extent of management support and the organizational setting (public or private). The author argues that further studies should be devoted to incorporate people's goals in the analysis, as they affect the duration, intensity and direction of proactive actions. Bad goals may even lead to counterproductive proactive behaviours, for example when they are motivated by personal interests that are not aligned with those of the organization or when they substitute other necessary core activities.

Parker et al. (2006) enriches the list by adding two other categories. Cognitive motivational states refer to: role breadth self-efficacy, mentioned earlier; control appraisals, which is the individuals' expectations that they will feel control over situations and particularly that they can have an impact on work outcomes; change orientation, related to how individuals deal with negative consequences of changes caused by their initiatives and to what extent they feel responsible to bring about improvements; flexible role orientation, meaning how one considers the breadth of the assigned set of tasks (the broader they are the more likely one tends to enact improvements beyond its job domain).

A second category is the perceived work environment. This encompasses job autonomy, because it gives workers responsibility and control over their tasks and outcomes, and supportive climate, both with respect to peers and supervisors. Indeed, co-workers trust is positively associated with proactivity because individuals gain confidence by others and believe in their support. The same reasoning applies with supportive management, since it encourages employees to self-manage and self-direct their work. This, however, can result in conflicting behaviours when workers challenge the decision and the authority of their supervisors.

More recently, Cai et al. (2019) provided a comprehensive review of the social antecedents of proactivity, particularly focusing on leader-related factors. It has been shown that certain leadership styles influence individuals' proactive behaviours. Among them, transformational leadership emphasizes the leader's role in introducing and implementing changes through providing a challenging vision of the future, stimulating subordinates' intellect, and inspiring them to go beyond expectations (Galeazzo, Furlan, 2019). Empowering leadership, instead, explicitly encourages autonomy, control, and independence. Besides general styles, specific leader's behaviours are also important; for example, welcoming and promoting employees' ideas, showing care and interest in their efforts, delegating responsibilities and treating them fairly are all beneficial to proactivity. Finally, other factors are the number and intensity of leader-employee exchanges and the leader's personal attributes.

Only few studies focus on team-related factors affecting proactivity, even though employees taking charge of improvement activities inevitably affect also teammates' workplace. Moreover, "employees often have more frequent interactions with their team members than with their leaders" (Cai et al., 2019, p. 222). The authors find that team climate, the shared perception of the way things are going and how things are done in teams, and an atmosphere of encouragement and support of proactive behaviour, are positively correlated with proactivity. This holds true also for interpersonal interactions with co-workers: when team members treat each other with respect and trust, as depicted by favourable interpersonal norms, the team is likely to engage in collective proactive behaviour, probably because of the low perceived risk and high perceived encouragement of initiating changes.

However, literature lacks studies that explore how individual proactive behaviours are related to shared cognition in teams or the existence of shared mental models (SMM) within the groups where each individual works. We shall then examine how these linkages affect performance, in particular the effectiveness of improvement routines. First, a theoretical explanation is provided on organizational routines, as well as on mental models and the relationship between each other.

2.2 Organizational routines

An organizational routine is widely recognized by literature as a repetitive and recognizable pattern of interdependent actions carried out by multiple actors. They can also be documented with a set of standard procedures or formal rules, but it is not an essential part of the definition (Feldman, Pentland, 2003). Among the various types of routines, the focus of this paper will be on improvement routines, such as those of lean management and Six Sigma. Anand et al. (2009) characterize them as routines with the aim of developing dynamic capabilities, which are learned and stable patterns of collective activities, through which the organization creates and modifies its operating routines in pursuit of improved effectiveness.

Feldman and Pentland (2003) identify two fundamental aspects of organizational routines: the ostensive and the performative. The ostensive aspect is the abstract, the ideal form of the routine, which shapes the perceptions of what the routine is and how it works. It can be codified into different artefacts, such as written rules, taken-for-granted norms or standard operating procedures, but it is generally not directly observable. Alone, it is not sufficient to perform a routine. It provides the necessary resources to act, but it ultimately does not fully determine action, which is why it is strictly interrelated with the performative aspect of the routine, much

more practical. This second dimension encompasses the specific actions, taken by specific actors in specific places and times, to perform the routine. Even though they are carried out against a more or less precise background of rules and expectations, there is always a component of novelty and improvisation. Variations, modifications and even total re-inventions are always possible, because routine participants interpret situations differently, in order to make sense of what they are doing and accommodate for the particular context which they are in.

Both these aspects are necessary and equally important and must not be neglected. The ostensive aspect serves as a guidance, a template of behaviours and actions individuals need to take. Moreover, it can be used to legitimate the actions taken retrospectively, when someone challenges them, or as a reference to understand something that is otherwise incomprehensible. Individuals cannot perform the routine without having an understanding of how the routine should be conducted, but, through the experiential learning of actually practicing it, they can maintain, modify or recreate new ostensive aspects that better fit with the context. For this reason, memory has a fundamental role: it stores the information from which individuals retrieve their perception of the routine. As they remember successful actions through the performance aspect, they memorize them, displacing the search phase and enacting better problem solving patterns (Miller, Pentland and Choi, 2012).

The ostensive aspect becomes a collection of individuals' understandings of the routine, embedded in their memory and incorporating the subjective views of each participant. Because of this, it is likely to be distributed unevenly, different for each individual and influenced by their role, background and point of view. Nonetheless, some authors have argued and empirically tried to demonstrate that individuals can develop a shared and aligned understanding of the routine, via continuous interactions and cooperation.

For example, Bapuji et al. (2018) assert that understanding-based redesign of routines by revising the formal structures (rules or standard operating procedures) and changing the tools employed during routine performances can lead to a better alignment of participants' perception of their role in the routine. Despite this can cause temporary disruptions in the established pattern of actions and in individuals' coordination, it will eventually improve the overall effectiveness of the routine, because it facilitates interactions, clarifies the role of participants and gives them a better sense of what tools are more useful and in what situations. The results of their study on a towel changing procedure in a hotel demonstrated that a coherent redesign of the routine improves its effectiveness (in this particular case, the number of towels asked to be exchanged by clients was reduced, with savings in terms of water and staff burden).

On the contrary, Zbaracki and Bergen (2010) show that a misalignment over the goal of the routine due to asymmetric information and diversified interests introduces variability in the performative aspect, which weakens the guiding dimension of the ostensive aspect, since individuals will have a different understanding in their memory. Sometimes this variability can even turn into conflicts among participants, causing the routine to be unstable, less sustainable and, as such, much less effective.

This, for example, happened in a manufacturing firm in a price adjustment routine, where both the marketing group and sales force representatives participated. The roles and sequence of actions were clear to everybody and the routine was quite stable: marketing members studied customers and competitors to come up with a price list, upon which sales members made adjustments to take care of the firm's interests and match them with legitimate business needs of customers (for instance, granting a discount over larger purchases). Then the negotiated price moved up the hierarchy ladder for approval. When price adjustments were small, no problem arose. On the contrary, in the case of big exceptional price changes, conflicts emerged. The marketing group thought of the price list as the best way to signal the company's market position, due to its visibility, and large price changes for specific customers could create confusion. On the other hand, sales force claimed that rebates, discounts and special terms were useful to allow the company to address different segments that had different needs. These dissenting opinions expanded also on other elements of the routine, for example over who had the best information and the extent of each group's jurisdiction, aggravating conflicts and disrupting its ordinary course.

Therefore, we expect that sharing the ostensive aspect of a routine within teams leads to more robust and sustainable improvement routines, characterized by less conflicts and a shared alignment over common goals.

2.3 Shared mental models

Participants' shared understanding of the routine are shaped by their mental models, defined by Rouse and Morris (1986) as "mechanisms whereby humans generate descriptions of system purpose and form, explanations of system functioning and observed system states, and predictions of future system states". In other words, mental models are organized and structured knowledge frameworks stored in the individual's memory, that enable information processing in a rapid and flexible manner, via complex cognitive functioning (Cannon-Bowers, Salas and

Converse, 1993). Specifically, mental models allow people to predict and explain the behaviour of the world around them, to recognize and remember relationships among components of the environment, to construct expectations for what is likely to occur next and to decide which actions to take (Mathieu et al., 2000).

Organizational routines by definition involve multiple actors. This requires to understand how individual mental models aggregate at the collective level. Team mental models are indeed different: although rooted in individual cognitive processes, they emerge from a pattern of interrelated interactions among team members, which are contextualized based on the specific elements of the surrounding social environment (Guiette, Vandenbempt, 2013).

These team mental models are said to be shared between members when teammates organize their knowledge of team tasks, equipment, roles, goals, and abilities in a similar fashion. They provide a context in which communication can be interpreted and a basis for predicting the needs and behaviours of the other components. This is especially useful when time and circumstances do not allow for overt and lengthy communication neither for strategizing among team members (Lim, Klein, 2006). Team members must rely on pre-existing knowledge to predict the behaviours of their teammates, select actions that are consistent with them and respond in a coordinated manner to urgent high stakes and/or novel issues. In these high-workload situations, Stout et al. (1999) demonstrated that high-performing teams used better communication strategies because they engaged in mental modelling activities during low-workload periods, such as planning and sharing informational requirements.

Similarly, Waller et al. (2004) studied control crews[9] performance in varying degrees of workloads: low means monitoring activities of signals or changes in specific parameters; medium refers to routine situations of the implementation of standard operating procedures to maintain or improve the functioning of the controlled system; high is about non-routine circumstances, where unexpected problems need to be addressed to avoid potential disruptions or system failures. The results of a study on 14 control room crews of nuclear power plants assessed that high-performing crews engaged in mental modelling activities during low and medium workloads periods by using face-to-face communication and dedicating less attention to time. This enabled them to improve their performances during abnormal and stressful situations. These findings suggest that developing shared mental models has a positive effect on team performances, since it facilitates communication between members and coordination of activities, even during exceptional non-routine circumstances.

[9] Highly skilled teams who work and train together to monitor system interfaces and keep systems at equilibrium, prevalent in sectors where performance reliability is crucial (aviation, naval operations, nuclear power plants etc.)

Furthermore, shared mental models allow to exploit non-routine situations for renewing and enhancing existent routine. Dionysiou and Tsoukas (2013) argue that routine creation and renewal are explained through the particular mechanism of role taking, although it is not the only one. During the actual performance, participants take into account fellow participants' roles (their actual and potential understandings, ideas, opinions, and actions) with respect to the collective activity, in order to develop a joint, situated understanding of the concrete situation at hand, identify appropriate actions and align their individual lines of action accordingly. Here, joint means that it is the product of interactions among team members, while being situated requires the understanding to be strictly relative to the surrounding context. Consequently, participants are able to make sense of what others are doing and thinking, and create what the authors call a "schema" of their role in the routine and of their contribution. Through experience and continuous repetition, behaviours become complementary and fit into a specific pattern of actions, while these schemata are developed and modified to update the extant ostensive aspect of the routine. Bapuji et al. (2018) reinforce this reasoning, stressing that a shared schemata "provides a more stable foundation for the pattern of actions that constitutes the routine, helps to facilitate the coordination among routine participants, and thereby reduces the likelihood of problems arising from the exchanges among them." (p. 2144), which clearly increase the routine effectiveness.

Both authors use the term "schemata" instead of "mental models" in their papers. Schemata are knowledge structures that act as data reduction devices enabling individuals to deal with complex and confusing contexts (Rerup, Feldman, 2011). They provide templates against which members can match past and future organizational experiences, so that a meaningful explanation is attributed and responses to those events are regulated upon it (Balogun, Johnson, 2005).

Mohammed et al. (2000) address the lack literature has on the conceptual development of mental models, which would help clarifying the distinction between them and schemata. According to the authors, team mental models are team members' shared understandings and mental representations of knowledge or beliefs about key elements of the team's relevant environment. It is important here to distinguish between knowledge structures and belief structures. The former refers to the "descriptive states of nature that one knows to be true", while the latter recalls the "desired states that one prefers, expects, or demands" (Mohammed et al., 2000, p. 125). It follows that schemata can be considered as a component of mental models, as they lack this second structure. Drawing on Mathieu et al. (2000), which also states that they are quite similar concepts, for simplicity schemata will be used as a proxy of mental models in the remaining part of the present research.

At the organizational level, Rerup and Feldman (2011) define organizational interpretive schemata as "a set of shared assumptions, values and frames of reference that give meaning to everyday activities and guide how organization members think and act" (p. 578). They are expressed over time as both espoused and enacted schemata. An espoused schema is a preferred (re)definition of organizational reality that individuals hope to enact and claim their organization is or should be about. An enacted schema is the organization-specific patterns that transform the intentions of the espoused schema into a structure of realized cognition and actions. These two components may be very different. During times of stability, when existing schemata and patterns of interaction are not challenged, some level of shared understanding needs to exist for coordinated activity to occur. The commonality between individuals' schemata leads to an enacted reality at group level in the form of routines, rituals, systems, norms, assumptions and beliefs (Balogun, Johnson, 2005). On the other hand, in the case of novel situations that require unscripted behaviours, actors articulate new espoused schemata with an updated common base for action that can solve the problem at stake. The new enacted schemata may eventually lead to a further revision of the espoused one.

Many authors claim there can be several shared mental models co-existing at any given point in time (Cannon-Bowers, Salas and Converse, 1993; Lim, Klein, 2006; Mathieu et al., 2000). Regardless, what are the key elements that cannot be omitted among the shared understandings to improve team effectiveness consistently? Mathieu et al. (2000) identifies two major content domains of mental models: task-related and team-related. Taskwork mental model entails the understanding of the technology, the equipment and the tools with which members will interact. Although this is likely to be the more stable and the easiest to be shared, its dynamics of interaction and potential issues must be taken into account. Moreover, it refers to job and task models, which describe how the task is accomplished in terms of procedures, strategies, potential contingencies and environment conditions. This part becomes more relevant the more the task is complex and unpredictable. These mental models enable participants to interpret information and behaviours required to perform the task in a similar way, resulting in improved task effectiveness.

Teamwork is composed of team interaction, which describes the roles and responsibilities of team members, their interaction patterns, information flow, as well as the communication channels, role interdependencies and information sources. It allows members to create shared expectations and predict interactions, making groups more adaptable. Moreover, it refers to team members themselves: their knowledge, pool of skills and abilities, attitudes, preferences

and tendencies, strength and weaknesses (Lim, Klein, 2006). This enables participants to better tailor their actions according to other teammates' behaviours and capabilities.
The more knowledge about one another and the more accurate the information is, the more automatic and effective the process can be. As such, team members need to perform task-related functions well and, at the same time, work well together as a team.

2.4 The theoretical model

Given this background on improvement routines and shared mental models literature, we now begin building a theoretical model that connects mental models (namely, taskwork and teamwork) with proactivity (respectively, proactive problem solving and proactive idea implementation). We will hypothesize that both these elements have a direct impact on team performance and that shared mental models influence employees' proactive behaviours, therefore exerting an indirect positive effect as well. These hypotheses will be then tested through the analysis of the results of a survey administered to operators of two Italian firms, described in the following chapter. Figure 2.2 illustrates a visual representation of the underlying theoretical model.

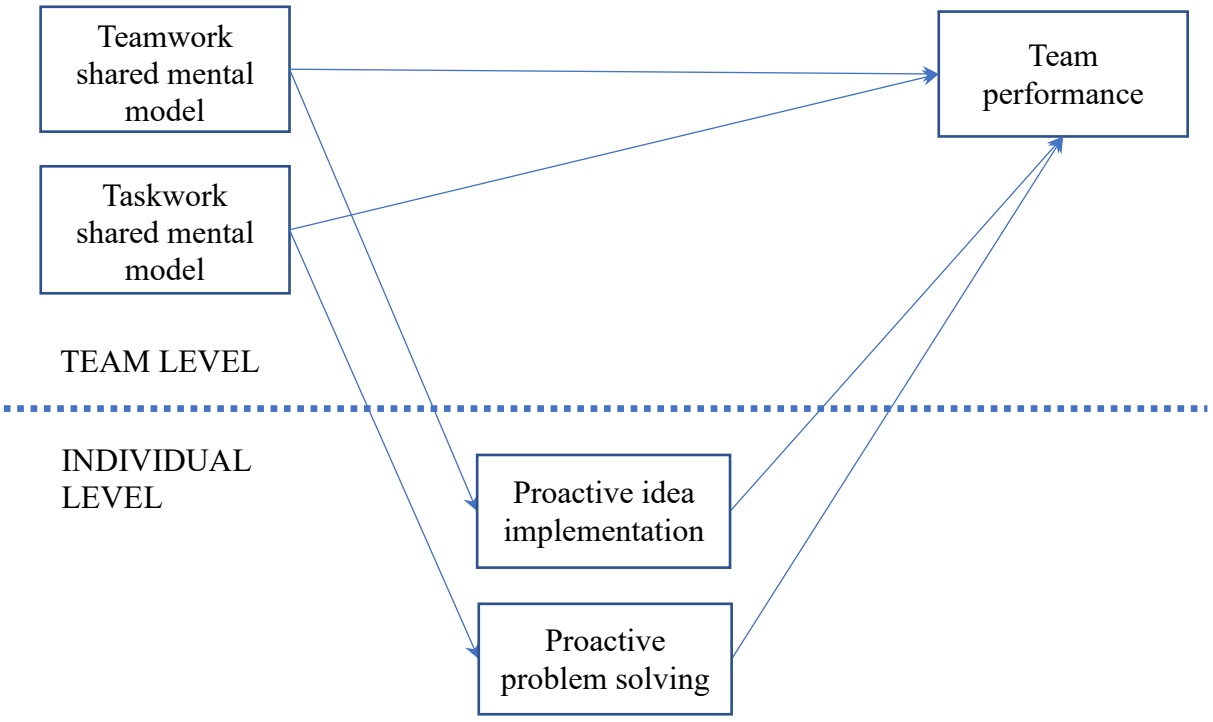

***Figure 2.8**: The theoretical model. Image developed by the author*

2.4.1 The direct effect of shared mental models on performance

Several studies emphasize the necessity to analyse the effects of the above-mentioned two main domains of mental models on performance, because they are likely to have unique consequences on team effectiveness. Mathieu et al. (2000) conducted a laboratory experiment involving 56 dyads of undergraduate students trying to pilot military airplanes on a flight simulation software. The aim was demonstrating empirically the positive and distinguishable effects of shared team and task mental models on team performance, but results were contrasting. Only teamwork had a positive correlation with team effectiveness, while taskwork only showed an indirect effect through the mediation of the positive impact on team processes (i.e. strategy formation, coordination and cooperation). On the contrary, in the replication study of Mathieu et al. (2005), with 70 dyads of undergraduate students, task mental models exhibited a direct positive relationship with team performance, whereas there was none between teamwork and team effectiveness. However, the authors attributed these differences to the peculiar characteristics of the sample and the research method.

Rentsch and Klimoski (2001) focused on team mental models, particularly on team members' schema agreement component, defined as "the degree to which team members' schemata are similar in content and/or structure" (p. 108). Unlike most of previous research, their study was conducted in a natural setting, involving 315 individuals representing 41 teams from a U.S. Department of Defence organization. They showed that similar teamwork schemata were positively correlated to all three dimensions of team effectiveness (client satisfaction, team viability, team member growth), through the improvement of team coordination and interaction and the development of a common interpretation of team processes.

Similarly, Lim and Klein (2006) tested the hypothesis that teams whose members organize and structure their team-related knowledge in a similar fashion are likely to better coordinate their activities. In a field study with 71 combat teams from Singapore, they found a direct relationship between team members' mental models and team effectiveness, probably reflecting the specific context of research. Under high stress and intense time pressure, teams must have a solid shared understanding of the emerging situation and of the required collective actions to succeed.

Both Lim and Klein (2006) and Mathieu et al. (2005) verified the relationship between team effectiveness and another component of shared team mental models, team members' schema accuracy, which explains the quality level of the models in terms of priorities, expertise, goals and contextual circumstances. Only Lim and Klein (2006) found that accuracy was instrumental to team performance.

Despite these contradictory results, overall scholars agree that both task and team shared mental models exert a non-negative, if not positive, effect on team performances. Nonetheless, Kellermanns et al. (2008) tried to weight the alleged benefits of shared mental models against what could be damaging instead. When members share similar knowledge and understandings, they are able to communicate more effectively, coordinate more fluently and comprehend one another's perspectives, because they interpret cues in the same manner and are more likely to make compatible decisions. Moreover, mental model similarity diminishes the likelihood of conflicts and, therefore, team members are more focused on the issues at stake, rather than undermining decision making due to bad feelings and resentment over different opinions. On the other hand, too much reliance on shared models may cause the team to underutilize the diversity of its components, which may lead to single-minded decisions or, at extreme levels, to groupthink, particularly deleterious in the case of complex non-routine situations. The authors claim that a balance between norms that guarantee constructive confrontation and a sufficient degree of mental model similarity can and should be achieved to strike a profitable equilibrium.
Given these insights and considering team performance in terms of improvement routines, the first two hypotheses we want to test:

- HYPOTHESIS 1
  Shared taskwork mental model is positively associated with the effectiveness of improvement routines

- HYPOTHESIS 2
  Shared teamwork mental model is positively associated with the effectiveness of improvement routines

2.4.2 The indirect effect of shared mental models on performance

Team performance, including that of improvement routines, is affected by a wide variety of work group characteristics, abundantly treated and studied by several scholars. Hyatt and Ruddy (1997) investigated the relationship between a number of these (commitment to common goals, work group morale and confidence, effective communication, trust and proactivity, just to name a few) and team performance in a study on customer service work groups and their managers. Proactivity was defined as the extent to which work group members actively and intentionally

search for areas for continuous improvement, constantly revise work processes, seek alternative or innovative solutions to problems and address issues before they become major obstacles. This definition is in line with what Parker et al. (2006) called "proactive work behaviour" and the authors show that it was significantly correlated with several measures of work group effectiveness selected for the specific sample.

Also Wu et al. (2014) argue that proactivity positively contributes to the individual performance and ultimately to organizational creativity and effectiveness. In particular, they focus on individual innovation behaviour, a specific type of proactive behaviour that was previously described as "proactive idea implementation" (Parker et al., 2006). This refers to an individual's intentional engagement in generating and applying new ideas and approaches in the workplace, so that the role performance, the group or the organization can benefit from it. As it facilitates new service and product development and better ways of doing things, scholars have widely analysed what could be its antecedents. Wu et al. (2014) investigated on the role of the need for cognition, the individual's tendency to engage and enjoy thinking. They found that people with a high need for cognition would have a positive attitude toward novelty, complexity, and uncertainty, in particular towards their own ideas, which enhances their persistence in their pursuit. Moreover, these people are better able to engage in information processing and, armed with higher confidence in their ideas, they are more likely to develop persuasive arguments.

At the individual level, proactivity means engaging in a cognitive effort to challenge the *status quo* and pursue improvement opportunities. The routine participant analyses the current routine to adapt it to future alternative scenarios and make sense of the consequences following the hypothesized changes. The individual is required to identify the features and potentials of a situation, reflect on their possible connections, unravel cause-and-effect relationships and, eventually, update his/her mental representations according to the desired changes.

However, improvement routines are socially constructed processes where individuals are asked to coordinate with teammates in their efforts to generate and accomplish change (Vough et al., 2017). It follows that understanding how proactivity can affect improvement routines effectiveness requires examining not only individual behaviours, but also how team-level changes are initiated. Therefore, at the team level, proactive work behaviour entails not only the cognitive efforts to project oneself into future events, but also to accurately predict how the team will collectively interpret and react to variations in the work context.

Many studies fail to recognize that team-level changes can be successful (thereby resulting in effective team performance) only if proactive employees are able to draw accurate inferences about the team dynamic functioning. As such, we claim that shared mental models exert an

indirect effect on team performance by affecting two dimensions of employees' proactive behaviour, namely proactive problem solving (PPS) and proactive idea implementation (PII).

The indirect effect of taskwork mental models on team performance via PPS

Research suggests that proactivity may facilitate job performance because proactive individuals select and create situations that enhance the likelihood of high levels of performance (Thomas, Whitman and Viswesvaran, 2010). Proactive tendencies may affect performance by impelling individuals to study the surrounding environment in a rigorous manner, helping them to anticipate potential problems and influence environmental changes. These kinds of investigations and manipulations of work environments may also provide employees with instrumental insights into how key organizational systems function. Finally, from a person–environment fit perspective, proactivity may also help employees to actively customize their environments in a way that accentuates individual strengths and optimizes performance.

More in detail, we focus here on the specific proactive behaviour of problem solving. An organizational routine often presents problems to its participants, which are then tasked to find and implement fast and effective solutions. Individuals can adopt two different behavioural attitudes (Galeazzo, Furlan, 2019; Mohaghegh, Furlan, 2019). The first one entails reasoning intuitively with minimal cognitive efforts and is called intuitive problem solving (IPS). The second approach relies on analytical reasoning and requires deliberative cognitive efforts, called systematic problem solving (SPS), or again using Parker's (2006) taxonomy, proactive problem solving (PPS). IPS uses short-term remedies, quick heuristics and mental shortcuts with the aim of promptly fixing the problem. In so doing, the issue is solved only temporarily and, although it generates short-run benefits and simplifies its complexity, it can lead to severe and systematic errors. Examples are increasing the batch size to compensate for quality problems or repairing a leaking machine by simply attaching a patch to it: they do not solve the problem entirely, but only fix it to minimize short-run damages. PPS, or SPS, is instead a more robust and sustainable solution, whose purpose is to fundamentally resolve problems by identifying and eliminating their root-cause. Structured actions follow, in which the issue is defined and thoroughly analysed, a diagnosis is reached and a solution is carefully selected after considering several potential alternatives. An example of this approach is adopting the lean SPDCA cycle, because it prevents the recurrence of problems and contributes to the long term continuous improvement initiative.

By systematically seeking definitive solutions, shop floor employees not only reduce inefficiencies and avoid the reoccurrence of problems, but also better tailor their responses to those problems emerging during routine performance and decrease the chances of making the same mistakes. Through the repetition of these appropriate solutions, standardized methods and practises are (re)created and implemented by each team member, which continuously rejuvenate the ostensive aspect of the routine and help the team in better reaching their goals (Furlan, Galeazzo and Paggiaro, 2019). In line with these reasoning, we suggest that proactive problem solving enhances team effectiveness by limiting the chances of reiterated disruptions during routine performance:

- HYPOTHESIS 3
  Team members' PPS behaviour is positively associated with improvement routines' effectiveness

However, shared mental models contribution is fundamental for team effectiveness. PPS indeed causes a disruption between the ostensive and the performative aspect of the routine: individuals willfully introduce new elements in the ostensive aspect to make sense and solve a problem that has caused inefficiencies or interruptions of the activity (Guiette, Vandembempt, 2013), thereby altering their current performances. Anyway, successfully adopting such behaviour requires understanding the underlying causes and how the team task was affected by the problem. Shared taskwork mental models allows team members to be aligned on what is the best equipment to use, what are favourable environmental conditions, how strategies and task contingencies are deployed and so on. These shared information are the benchmark against which each participant will compare the disruption, therefore participants will collectively understand the root cause of the problem and how to act on it. Moreover, shared taskwork allows members to anticipate others' actions as well as task needs, enhancing their confidence in challenging work settings and proposing new solutions. This creates a psychologically safe environment in which participants are encouraged to express their opinions, new ideas are welcomed and knowledge is frequently shared with a common language, so that the ostensive aspect is intentionally modified for long term improvements (Furlan, Galeazzo and Paggiaro, 2019). For these reasons, we claim that taskwork similarity supports and favours proactive problem solving, and therefore has an indirect effect on team routine perfomance.

- HYPOTHESIS 4
  Shared taskwork mental models are positively associated with team members' PPS behaviour

Peng et al. (2008) argue that routines are a critical source of operations capabilities, which are in turn fundamental for the creation of a sustainable competitive advantage. In particular, they consider improvement routines as a form of manufacturing innovation, which leads to the improvement of existing products and processes or the development of new ones, a crucial point in reaching competitive advantages. Indeed, operations management literature agrees that a better execution of these routines guarantees a way to combat increasing competition and shrinking products life cycle and contributes to the achievement of organizational objectives.
Improvement routines effectiveness, therefore, requires employees to be capable of finding and succesfully implementing new ideas or changes, both large and small, in addition to be able to identify emerging problems and the corresponding sustainable solutions. Recalling Parker et al. (2006, p. 637), individuals should "take charge of an idea for improving the workplace, either by voicing the idea to others or by self-implementing the idea", that is adopting a proactive idea implementation behaviour (PII).
Intentionally pursuing innovative and potentially enhanced ways of executing work and accomplishing team's objectives is expected to be directly correlated to team operational performance. Routine participants undertake a hands-on approach by introducing small or large changes to the performative aspect of the routine. Those that are successful in coping with emerging issues or improve the efficiency of the activity will then update team members mental models by renewing the ostensive aspect. This eventually leads to an improvement of the routine effectiveness.

- HYPOTHESIS 5
  Team members' PII behaviour is positively associated with improvement routines' effectiveness

Nonetheless, improvement routines are social processes that involve the participation and coordination of multiple individuals. Any new idea or change, regardless of who is proposing it, is inevitably subjected to other teammates' examination and approval, since it will affect the workplace where the whole team works. Several studies show that individuals' propensity to adopt a proactive idea implementation behaviour relies on team-related factors. Axtell et al. (2008), for example, found that individual, job, group, relationship and organizational factors all have an impact on individual innovation, but suggestion of novel or useful ideas (the first phase of the innovation process) was more associated with individual and job elements, whereas idea implementation (the second phase) was more influenced by team and organizational

factors. Namely, in a study of 148 operators working for a beverages manufacturer, those individuals that were more confident across a wide range of work areas (i.e. they had a greater role breadth self-efficacy), had more autonomy and expressed greater concern for work issues were those who reported making most suggestions. On the other hand, those individuals who experienced greater team leader support, better team methods, greater diversity of team responsibilities, more support for innovation and higher levels of participation and support from management were those who reported that most of their suggestions were put into practice.

Furthermore, Anderson and West (1998) investigated and identified four team-level factors that contribute to enhance group innovative performance. Clearly defined work objectives, more frequent and active participation in the decision-making process, greater emphasis on task performance through constructive discussions and control systems, a general climate of support and encouragement of new ideas are all group factors that increase the likelihood for team members to offer and implement changes for improving work settings and processes.

Following this line of reasoning, we argue that shared teamwork mental models fosters the adoption of PII behaviours. When team members possess the same understandings of routine participants' knowledge, skills, attitudes, as well as their roles, responsibilities and interaction patterns (Lim, Klein, 2006), they are more likely to express their opinions and welcome those of the others. Moreover, as long as the expertise is evenly distributed, they are more likely to feel responsible for team success and, therefore, are willing to exert higher efforts in proposing or implementing new ideas for improvement[10].

However, innovation is a risky endeavour. Baer (2012) observes that "as creative ideas imply departures from or extensions of existing products, services, or ways of doing things, uncertainty is a signature feature of most creative ideas. Unfortunately, uncertainty often provokes disputes, caused by differences in viewpoints among those who are affected by the ideas, and such conflicts, in turn, may result in unnecessary delays in implementation or its ultimate failure" (p. 1105). Moreover, the implementation of new ideas typically implies challenging established power structures or interests in an organization, which causes resistance and increases the likelihood of them being rejected, regardless of how promising an idea may be. Consequently, people may suffer losses of reputation, as well as a withdrawal of the trust of friends and sponsors.

[10] This is different from Parker et al. (2006), since the authors attributed individual sense of ownership of the unit's goals to the degree of flexible role orientation, defined as the breadth of perceived accountability beyond the immediate array of technical tasks. Here, the emphasis is put on the individual perception of the distribution of responsibilities and whether he/she recognizes to be a part of a collective process, like improvement routines

In a study of 216 employees from a global agricultural processing firm, Baer (2012) provides evidence that individuals' implementation efforts are significantly affected by the degree to which they sense that these efforts will result in desirable outcomes. To the extent that teamwork mental models about team functioning and interactions are shared, individuals show more propensity to voice or take charge of idea implementation, drawing on the common expectations of team behaviour and the anticipation of teammates actions that these mental models provide. The more they are accurate in predicting the reactions and acceptancy of change of their co-workers, the more each team member is likely to self-implement novel or useful ideas.

In sum, shared teamwork mental models allow teammates to work together as a coherent unit, to feel responsible for the team performance (Cannon-Bowers, Salas and Converse, 1993) and to predict the team likelihood of reaching a desired outcome, thereby supporting the adoption of proactive idea implementation behaviours.

- HYPOTHESIS 6

  Shared teamwork mental models are positively associated with team members' PII behaviour

3. EMPIRICAL ANALYSIS

In the last part of the present work, an empirical analysis is conducted on two real firm cases to test whether the hypotheses formulated in the previous chapter are correct. We will be administering a questionnaire to some number of their employees, mainly from the production area.

The first company at hand is Cartotecnica Postumia S.p.A (Figure 3.1), where I had an internship experience. Located in Carmignano di Brenta (province of Padua, Italy), it is a relatively small family owned firm, at its third generation, producing and selling printed paper bags[11]. It was founded by Ettore Gava in 1966 and has grown ever since, now registering 22 million revenues and more than 130 employees, with a worldwide span of action (West Europe and North America in particular). It has three main production lines: printed paper bags with a squared base, dedicated to the food industry (especially for flour, sugar and rice), providing 38% of the turnover; printed paper reels, mostly for the same industries, accounting for about 18% of revenues; printed shopping bags for all kinds of shops and stores, representing the last 44%. It can boast several accomplishments in terms of quality, food safety management and environmental certificates (e.g. ISO 9001:2015, BRC global standard, PEFC ST 2002:2013), as well as yearly prizes for the printing quality (e.g. BestinFlexo and European FTA Diamond awards for first positions in flexo print on paper).

***Figure 3.1**: The logo of Cartotecnica Postumia S.p.A.*

Its mission is "We care about your identity", as each paper bag is customized to meet the necessities of the specific customer, so that their clients can recognize them and the message they want to convey. To this commitment, from 2016 the firm has added the lean principles of creating value for their customers, in the fastest way possible, without waste, when and in the quantity they need it.

This was the beginning of a long lean transformation journey of the whole company, which brought several interesting results. The firm has been organized in value streams and transversal support functions, processes have been standardized and connected to each other and hundreds of hours of training and formation have been used to develop internal skills like problem solving. It undertook various strategies to improve performances and evolve the organization,

[11] Fun fact: they produce more than 100 million meters of printed paper every year, which can wrap the Earth almost three times!

creating specific projects with a clear owner and involving as much people and departments as possible. For example, a project was about implementing SMED activities to reduce the high set-up cost typical of this sector, another led to an improvement of the lead time by standardizing the process of colour preparation and operators motion was diminished by 70% (from 11.9 km walked per day to 3.4) thanks to a layout rethinking. Overall, these efforts translated into lower costs, higher flexibility and more stable processes, an excellent recipe for success.

The second firm is Silikomart Industries S.r.l (Figure 3.2). Founded in 2002 in Pianiga, between Venice and Padua (Italy), it soon established itself as a leading company in the design and production of platinum silicone components and products. In 2019, it registered almost 25 million revenues and 82 employees and it is looking to grow more in the future.

***Figure 3.2**: The logo of Silikomart Industries S.r.l.*

Silikomart offers a wide range of refined, innovative and Made-in-Italy products. Characterized by premium quality, functionality and aesthetics, they are versatile and ideal for several sectors, such as electronics, house and kitchenware, healthcare, lighting engineering and fashion, to name a few. All of them meet the strict regulatory and quality standards required, thanks to the high attention that the company puts into quality controls in all of the production stages.

Its corporate vision is about providing customers with innovative designs, fostered by a strong commitment in research and development, and Italian manufacturing expertise and style. A close-knit team of young talents in every department and the employees' shared passion for the business with Dario Martellato, the owner of the company, has guaranteed its success since the beginning.

We will now go more in detail into the methodology of the empirical study. Primarily, the survey sample and design are going to be explained. Then, the various preliminary statistical analysis are presented, to test the internal coherence and the validity of the constructs of the theoretical model, as well as the more advanced ones, namely the multiple regression model, which will provide insights on whether to support the hypotheses formulated before. Finally, the results will be shown, checked and interpreted to make a valuable contribution to the current literature on the topics analysed in this thesis.

3.1 Sample and survey design

The target survey population consisted of individuals working in teams, performing stable and repeated tasks in their daily job. Cartotecnica Postumia provided a sample of 10 teams, which accounted for about 100 operators and 10 team leaders. One team of 10 operators plus one team leader was discarded in the first place, as they belonged to the logistics and warehouse value stream. This VS is composed of teams of two to four people who do not work constantly with each other during the whole shift, therefore not guaranteeing a sufficient team dimension nor a high level of interaction, necessary for proactive behaviours to emerge. The other nine were picked from three different value streams (VS): three from the printing VS, three from the shopping paper bags VS and three from the industrial paper bags VS.

Silikomart Industries provided a sample of four teams, which accounted for about 20 operators and 4 team leaders. One team belonged to the post curing[12] production phase, one to the packaging and the last two to the warehouse.

Among them, some operators were not considered for various reasons, for example because of linguistic barriers or absence of the operators for injuries or programmed holidays during the administration period of the questionnaire. Surveys from the first team of eight employees and one team leader of the industrial VS of Cartotecnica Postumia were also discarded *ex-post* because of diffused errors in answer procedures.

The final sample consisted of 77 operators from 12 teams with just as many team leaders, gathered from the 31st of August to the 24th of September 2020. The average number of components per team was 7.5, of which 73% were men. Almost half of the respondents, 46%, are mainly comprised between 31 and 45 years old; only 3% have more than 60 years and about 24% and 27% of people have under 31 and between 46 and 60 years respectively. With regard to education, 44% have an elementary school degree, 24% a junior high school diploma, 29% possess a high school degree and only 3 people (almost 4%) have a university graduation.

To each team was given a survey on paper about their working activities, teamwork, work priorities and objectives, personality traits regarding proactivity, performance results and proposed ideas of improvement. Questions, all in closed format, were developed based on an in-depth review of knowledge management, operations management, and behavioural psychology literature. The questionnaire was divided in four sections: one for teamwork and

[12] This phase consists in a secondary cure of the silicone (the first one turns the material from the liquid state to solid through specific chemical processes), involving a heating period of time that reduces toxic by-products and improves the physical characteristics of the silicone

taskwork mental models, one for PPS and PII, one for potential antecedents of proactivity and the last one to gather general information.

As the respondents of this study were Italian (or spoke the language), but the questions were first developed in English, utilizing the approach of Brislin (1980) was critical to ensure that the original, target, and the back-translated versions of the questionnaire were equivalent to minimize cross-cultural issues. It consisted in following the set of guidelines provided by the author, such as avoiding vagueness wordings, employing the active form rather than passive and using short simple sentences; then the survey was translated in Italian and back-translated in English, guaranteeing a control of the adequacy of the translation.

Moreover, a series of precautions were taken. First, because common method variance[13] can bias the estimates of constructs' validity and reliability, as well as the parameter estimates of the relationship between two different constructs (MacKenzie, Podsakoff, 2012), team leaders were given the task to gauge their team members on the same questions. Their answers will also be used as a robustness check to further validate the findings of the present study.

Second, the problem of social desirability bias, the tendency of some people to respond to questions more as a result of their social acceptability than their true feelings (Podsakoff et al., 2003), was mitigated by designing certain questions both with positively and negatively worded statements. This to control for people who agree more frequently than disagree to questionnaire items, as they require a higher cognitive effort.

Additionally, alternative solutions to measure the respondents' ability to solve problems were implemented, involving a vignette-based technique similar to what Furlan et al. (2019) and Parker et al. (2006) have used in their own research. According to Choo et al. (2005), the use of a hypothetical scenario, representing a common concrete problem that the two firms faced, helps in offering a relevant and specific situation whereby problem-solving orientations could be measured. Anchoring survey responses by referencing real-life decision making or judgment-making situations tends to reduce measurement errors compared to asking questionnaire items without referencing a specified problem.

As far as what concerns survey administration, the interviewer initiated self-administered approach was used, in an attempt to combine the advantages of both methods (De Leeuw, Hox and Dillman, 2008). The interviewer, the author of the present work, personally handed out paper questionnaires to workers in the production site or gathered them in a room during their normal shift period. In either case, he was always available for assistance and clarification, if

[13] The variance that is attributable to the measurement method rather than to the constructs the measures represent, typically between 18 to 32% of the total variance (MacKenzie, Podsakoff, 2012)

needed, thereby making respondents feel safe and comfortable in completing the survey. A short briefing followed, to explain its content and provide some reassurance that reduces social desirability bias: the interviewer stressed the anonymity of the survey, its importance for the research and that supervisors and management would only receive a general summary of the results, which meant that they were not intended for any kind of work evaluations. Although some general information were requested (gender, age, education, firm and team experience), anonymity was preserved by highly categorizing them, so that matching surveys with respondents resulted very difficult. Still, each team will be assigned a distinct code to maintain confidentiality, but also to avoid confusion during the statistical elaborations. Moreover, when surveys were returned, the interviewer was able to check the appropriateness of the answer procedures, as well as whether some answers were missing. Finally, the self-administration approach guaranteed more privacy and absence of interference by the interviewer in the question-answer process.

There were no substantial differences in the answers between the two firms and the duration of the procedure was more or less the same, 25 minutes on average with a minimum of 15 and a maximum of 40.

3.2 Measures

The model is characterized by one dependent variable (team effectiveness) and four independent variables (teamwork and taskwork shared mental models, proactive problem solving, proactive idea implementation), along with a series of control variables. Nine of them are multi-item constructs with their own scales and number of items. The preliminary step will be verifying their reliability via specific statistical indexes, calculated using the Statistical Package for Social Science (SPSS) software provided by IBM. This entails testing their internal coherence, which means stating whether the items of the scale belong to the construct and if they coherently represent the same phenomenon in case of repeated measurements. For this reason, Cronbach's Alpha, Alpha-if-item deleted, item-to-total correlation and split-half reliability will be calculated and compared with their own acceptability thresholds.

Cronbach's Alpha is the most famous coefficient and, usually, values equal or above 0.7 are considered good. However, the more items are included in the scale the more this coefficient tends to rise, thus potentially undermining the reliability of the measurement or signalling redundancy. Therefore, it needs to be backed up by other indexes, such as the Alpha-if-item

deleted, which tells us what would be the value of α if a particular item has been excluded from the scale. When this index gives a value that is higher than Cronbach's Alpha, it means that the reliability of the scale should be better without that specific item; it is one of the best measure to decide whether to drop an item or not. The item-to-total correlation states the correlation between each item and a scale score that considers all the others and excludes that item. There are different opinions among scholars on what is the cut-off value that determines the goodness of the index; here we will follow Nunnally (1967) and choose 0.4. Finally, split-half reliability consists in splitting the scale in two parts and measuring the correlation between them; values above 0.6 are considered acceptable.

The next phase involves checking the validity of these scales, meaning whether they actually represent the phenomenon of interest we want to measure and that they are not related to other ones. Namely, the convergent validity is evaluated looking at the factor loadings that items of the same construct have with respect to it: values higher than |0.4| show that the correlation is strong and therefore the item should represent the construct; the sign of the correlation indicates the direction of the relationship. The discriminant validity requires to verify the existence of cross-loadings, that is if items show more than one high factor loading (>|0.4|) and so that they are correlated to more constructs; if they do, these elements may create problems for further elaborations and should probably be eliminated.

Validity will be assessed through a principal component analysis (PCA), a statistical technique that aims at reducing the dimensionality of the dataset and cleaning the measurement scales, thereby improving interpretability, but at the same time minimizing information loss. This consists in identifying the fewest number of new uncorrelated variables (the so-called principal components) that at the same time maximize the explained variance. These variables need to be at least equal to the number of theoretical constructs and as closer to it as possible, in order to avoid discriminant validity failures and instead optimize it.

Principal components can be identified through a number of methods. In this case, the Kaiser's rule was adopted[14], which chooses only variables that show eigenvalues greater than one, under the assumption that maintaining a factor that explains less than a single original variable is not psychometrically reasonable (Kaufman, Dunlap, 2000). Eleven principal components were found, a number that is largely satisfactory. Moreover, the cumulative variance explained by

[14] This is the most common method in determining the number of factors and it is quite simple. Other methods were discarded because of their inaccessibility and complexity (parallel analysis) or inherent subjectivity (scree plot)

them is slightly higher than 72%, which indicates that the model is optimal (values above 50% are considered acceptable).
To further check the adequacy of this model, a Bartlett's test of sphericity is conducted, which verifies:

- H_0: all correlations are equal to 0 (and therefore all variables are independent to each other)
- H_1: at least one correlation is different from 0

The very low p-value ($4.009*e^{-70}$) shows that the null hypothesis must be rejected; hence correlations are different from zero and significant at the 99% level.
Finally, we measured the Kaiser-Meyer-Olkin index of sampling adequacy (KMO), to assess how much of the variance is expressed through common factors. Since our model provided a value of 0.63, we can infer that it is not optimal from this point of view, but largely acceptable (acceptability starts from values higher than 0.5, while optimality from 0.7).
The output of this analysis is a matrix with factor loadings for each item that the reader can find in Appendix A. For further details on each item and construct, see the next sections.

3.2.1 Dependent variable

Let us start by examining the dependent variable. Team effectiveness was measured using eight items. Six were identified through a literature review on classic operational performance areas (Cua et al., 2001; Peng et al., 2008; Furlan, Vinelli, 2018): two items each on quality and flexibility, one item each on speed and dependability; then we added two more to account for safety and environmental responsibility.
Following the choice of Peng et al. (2008) and Furlan and Vinelli (2018), we used perceptual scales because objective measures yield results that are difficult to generalize to large populations, due to the plant-specific nature of manufacturing performance measures, and they usually suffer from missing values. Moreover, Ward et al. (1998) demonstrate that the data of their study "do not support the often-stated belief that "objective" questions requiring absolute estimates necessarily yield more reliable results than measures constructed from relative scales".
For each measure, respondents were asked to gauge their team performance on a Likert scale ranging from 1-"strongly disagree" to 5-"strongly agree". A team average of shop floor employees' responses was calculated and triangulated with those of their respective team

leaders to improve the accuracy of performance measurements. To do this, we calculated their interrater reliability index (IRR), which measures the relative consistency of ranking orders in the case of multiple raters via some type of correlation (in our case a Pearson-correlation). The majority of teams showed a poor correlation with that of their supervisor, close to zero, which entails a low interrater reliability. Therefore, we followed Cua et al. (2001) and used the average of team leader's evaluations as a measure of team effectiveness.

Preliminary statistical analysis revealed some problems, especially for the environmental sustainability item, which showed an Alpha-if-item deleted higher than Cronbach's Alpha (7.88 versus 7.54). Additionally, one item from the quality measure and one from flexibility had an item-to-total correlation lower than 0.4. The subsequent PCA analysis confirmed these issues, depicting high cross-loadings with different components. For these reasons, we decided to remove them, contributing to raise the KMO index and improving the discriminant validity as well (one factor clearly emerged and correlations grew).

3.2.2 Independent variables

Taskwork and teamwork shared mental models were the two independent variables of the model; PPS and PII were the two mediation variables.

Concerning taskwork and teamwork SMM constructs, we drew on the scales developed by Lim and Klein (2006). In particular, we asked respondents to judge and order seven statements based on their importance on a seven-point scale ranging from 1-the most important to 7-the least important. Taskwork SMM were elicited through statements describing team procedures, equipment and tasks, such as "Team members should conduct ordinary maintenance of their equipment and machinery" or "Team members should be aware of the current production progress". Teamwork SMM were elicited through concepts describing team characteristics and interaction processes, such as "Team members should communicate openly with each other" or "Team members should be aware of other team members' abilities".

To operationalize these constructs and assess the degree of similarity among teammates' cognitive structures we will adopt the interrater agreement index (IRA), which measures the absolute consensus in ratings provided by multiple raters through the variability among them. One of the most commonly used statistic is the r_{WG}, introduced by James, Demaree and Wolf in 1984. Since there are various types of formulas that adapt to different data samples and scales, we used the one that is suitable for a target measured by multiple raters on a single item. Indeed,

in our case this index was calculated for each singular item of both scales with the following formula (LeBreton et al., 2003):

$$r_{WG(1)} = 1 - (\frac{S_x^2}{\sigma_e^2})$$

where S_x^2 is the observed variance in judges ratings on variable X for a single target, while σ_e^2 is the expected variance on variable X when there is a complete lack of agreement. Because the ratio between them represents the proportion of observed variance that is error variance engendered by random responding, subtracting it from 1 yields an estimate of the proportional reduction in error variance. The lower the ratio the higher the agreement among them (and so the r_{WG}), signalling that only a small percentage of observed variance is attributable to random measurement error.

The statistic assumes values between 0 and 1 and the typically used heuristic for distinguishing high vs low reliability is 0.70, although more established tests or different purposes of assessment may need higher cut-off values. Nevertheless, sometimes it can give results that are either negative or higher than 1, probably due to sampling errors, existence of subgroups or inappropriate choices of null distributions for the calculation of the expected variance. Since this actually happened in the present research, we followed O'Neill (2017) and manually reset those values back to 0 and 1. Finally, single-item results were averaged to obtain a single measurement for each construct.

The proactive problem solving mediation variable had eight items, characterized by a Likert scale ranging from 1-"strongly disagree" to 5-"strongly agree". These were selected following Furlan et al. (2019) and included statements like "After following a course of action to solve a problem, I compare the actual outcome with the one I had anticipated" or "When a solution to a problem has failed, I do not examine why it didn't work".

Two items showed some non-acceptable values (item-to-total<0,4, Alpha-if-item deleted higher than Cronbach's Alpha) during the reliability and validity verification. Also the PCA analysis demonstrated poor discriminant validity, hence these items were removed. Namely, they were two negatively worded statements, very common elements to eliminate since respondents not always grasp their actual meaning.

The last independent variable is proactive idea implementation, composed of four items developed using the scales of Parker et al. (2006). Operators were required to indicate how many new ideas they had in the last 12 months, regardless of the following actions, on each of the following topics (on a scale including no new ideas, one or two new ideas, 3–10 new ideas and more than 10 new ideas): health and safety, saving money or cutting down costs, improving

process quality, environmental sustainability. When the answer was positive, that is they had at least one new idea, they had to indicate (a) whether they put the idea/s forward to anyone and, if so, to whom (no; yes, to my colleagues; yes, to a manager, supervisor, or other); and (b) whether the idea/s was implemented and by whom (no; yes, by myself; yes, by others). Following Parker et al. (2006), we considered suggesting ideas and have them implemented by someone as proactive behaviours. Therefore, 1 point was assigned if the individual performed only one of those actions and 2 in case both were taken. A score of 0 was given to those that did not have any new idea and to those who did but did not engage in any other proactive behaviour (even though he/she may be considered a creative person, it does not involve any proactive attempt to change the situation).

From a theoretical point of view, these items should not be included under the same construct, since they are not strictly correlated: an individual may have 10 new ideas for improving process quality or cutting costs, but none for safety and still be considered a proactive person. Nonetheless, preliminary statistical analyses showed positive values for all tests and indexes, but the PCA led to the deletion of the item on environmental sustainability because it clearly belonged to another principal component.

Following Furlan et al. (2019), we operationalized both PPS and PII by averaging the scores for each operator.

3.2.3 Control variables

Finally, we will control for a set of distal antecedents of proactive behaviour via cognitive-motivational state characteristics, retrieved from Parker et al. (2006) and following common literature on proactivity. In particular, we measured proactive personality (4 items), role breadth self-efficacy (6 items), supportive supervision (4 items) and flexible role orientation (5 items) to control for the possibility that shop-floor employees are more likely to engage in proactive behaviour due to individual-difference characteristics, while job autonomy (6 items) and co-workers trust (4 items) had the same objective with respect to contextual work environment.

Unfortunately, the reliability analysis exhibited some abnormalities for one item of the co-workers trust construct (high Alpha-if-item deleted, low item-to-total correlation) and one from that of flexible role orientation (all indexes were out of acceptable ranges). The validity analysis revealed issues concerning one item of role breadth self-efficacy and one of proactive personality, which both showed low convergent and discriminant validity. These four items were all removed and the overall goodness of the model was improved.

We will also control for a set of demographic variables, including gender (a dummy equal to 1 if the respondent is female, 0 otherwise), age (the average of an interval of 5 years), education (a four categories measure equal to 1-elementary school degree, 2-junior high school diploma, 3-high school degree and 4-university graduation) firm and team tenure (both four categories measures equal to 1-less than one year, 2-one to three years, 3-three to five years and 4-more than five years). Team leaders had to precisely specify their firm and team tenure to verify that they had more experience and competences, as well as a strong familiarity with team members' task and the organization in general.

Since only three people out of 77 had a university graduation (less than 4%), in the following model this category will collapse within that of high school degree to generally indicate higher education levels. The same reasoning applies to the category of three to five years for both firm and team tenure: respectively only four and six people selected this option (approximately 5% and 7% of the total), hence it will collapse within that of one to three years to generally indicate a medium experience.

Again, following Furlan et al. (2019), to operationalize these control variables scores were averaged for each operator.

3.3 Model and estimation method

Because we used averages of the items to operationalize all our constructs, the model's variables are manifest and not latent. Consequently, a confirmatory factor analysis, whose role is to find a measurement model with a reduced number of latent factors that are measured by observed variables, was no longer useful.

We therefore proceeded to analyse the zero-order correlations matrix, which reports all correlations between each couple of major variables without controlling for any influence from other variables. It is important to get a better sense of what subsequent more complicated analysis may reveal and this matrix gives us a first insight about the relations among the factors of interest.

Because our framework is multilevel, we analysed a zero-order correlation matrix for each level, one for the aggregate (teams) and one for the individual level (the single operators). Table 3.1 presents a zero-order correlation matrix of level 1 variables, that is at the individual level. It can be seen that proactive idea implementation, proactive personality and role breadth self-efficacy are significantly correlated with proactive problem solving with p values lower than

0.05 or even 0.01. Role breadth self-efficacy is also highly correlated with PII, along with job autonomy as they both show significance at a 99% confidence interval.

***Table 3.1**: Level 1 Correlations (n=77). Table developed by the author via the SPSS software*

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12
1. PPS	3.69	0.67												
2. PII	0.74	0.57	.24*											
3. Proactive Personality	3.23	0.88	.31**	.22										
4. Role Breadth Self-Efficacy	3.26	0.89	.35**	.39**	.43**									
5. Job Autonomy	2.61	1.14	-.05	.31**	-.09	.24*								
6. Co-workers Trust	3.36	1.03	-.01	-.20	-.21	-.04	.05							
7. Supportive Supervision	2.94	1.18	.02	-.05	-.19	.00	.17	.47**						
8. Flexible Role Orientation	2.87	0.77	.06	.23*	-.17	.07	.45**	.08	.28*					
9. Gender	0.29	0.45	.14	-.17	-.17	-.15	-.21	.01	.17	-.04				
10. Age	39.13	11.29	.05	.04	-.16	.04	-.13	.01	.15	-.07	.22			
11. Education	1.92	0.87	-.02	.07	-.01	-.11	.10	-.04	-.08	.07	-.08	-.53**		
12. Firm Tenure	2.45	0.68	-.01	.31**	-.06	.08	-.09	-.27*	-.29**	-.05	-.17	.39**	-.10	
13. Team Tenure	2.08	0.74	.11	.21	.02	.21	-.06	-.29*	-.18	.07	-.15	.32**	-.08	.66**

Notes: *M* and *SD* are used to represent mean and standard deviation, respectively. * indicates $p \leq 0.05$; ** indicates $p \leq 0.01$

Table 3.2 shows the zero-order correlation matrix of level 2, since it also includes variables at the or team level. Here, proactive personality is significantly associeted with team effectiveness, while team tenure is positively correlated with it, both registering p values lower than 0.05. Only taskwork shared mental models (Task SMM) show a high correlation with PPS, again with a p value lower than 0.05. Proactive personality remains highly associated with PII while job autonomy loses that relation, although it appears significantly correlated with task SMM at a 99% confidence interval. No variable shows a significant correlation with teamwork shared mental models (Team SMM).

The next step is actually estimating the relationships between the various factors of interest through OLS multiple regressions.

***Table 3.2**: Level 2 Correlations (n=12). Table developed by the author via the SPSS software*

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Team Effectiveness	3.53	0.79																
2. PPS	3.76	0.30	-.11															
3. PII	0.78	0.31	.41	.06														
4. Task SMM	0.39	0.19	-.30	.60*	-.12													
5. Team SMM	0.47	0.14	-.51	.11	-.03	.21												
6. Proactive Personality	3.27	0.43	-.61*	.34	-.03	.50	.34											
7. Role Breadth Self-Efficacy	3.35	0.48	.05	.37	.63*	.33	.24	.44										
8. Job Autonomy	2.71	0.59	-.12	.29	.01	.76**	.30	.60*	.58*									
9. Co-workers Trust	3.27	0.56	.14	-.41	-.30	-.42	-.22	-.67*	-.58*	-.61*								
10. Supportive Supervision	2.84	0.56	-.02	-.53	-.15	-.10	-.09	-.50	-.49	-.36	.75**							
11. Flexible Role Orientation	2.85	0.26	-.16	-.40	.33	.13	-.07	.14	.08	.04	-.10	.40						
12. Gender	0.30	0.24	.25	.00	-.05	.37	.22	-.30	-.07	.30	.31	.40	-.13					
13. Age	39.10	4.76	.44	-.25	.31	-.20	-.19	-.24	.23	-.10	.09	.28	.10	-.04				
14. Education	1.89	0.35	-.02	-.20	-.16	.06	.12	-.07	-.26	.10	-.18	-.08	.20	.29	-.48			
15. Firm Tenure	2.47	0.36	.57	-.22	.49	-.25	-.28	-.24	.13	-.19	-.04	.19	.26	-.15	.87**	-.40		
16. Team Tenure	2.14	0.44	.69*	.08	.55	.07	-.35	-.24	.17	.02	-.17	.10	.24	.08	.64*	-.25	.87**	

Notes: *M* and *SD* are used to represent mean and standard deviation, respectively, calculated at the team level for each level 1 variable. * indicates $p \leq 0.05$; ** indicates $p \leq 0.01$

3.3.1 The OLS multiple regressions

To estimate the relationships between our variables of interest we utilized a multiple regression model based on the ordinary least squares method (OLS), which measures the unknown parameters by minimizing the sum of the squared differences between the observed values of the dependent variable and those predicted by the linear function.

The first two regressions were run on the mediation variables PPS and PII using the R software for statistical computing. Proactive problem solving was predicted by taskwork SMM and all the control variables:

$$\eta_2 = 0.874 + 1.661\xi_1 + 0.173x_1 + 0.249x_2 - 0.133x_3 + 0.048x_4 - 0.023x_5 + 0.201x_6 + 0.131x_7 + 0.009x_8 + 0.071x_9 - 0.013x_{10} + 0.006x_{11} + \varepsilon$$

where η_2 is PPS, ξ_1 is taskwork SMM, x_i (i = 1, 2, ...11) represent all observed exogenous variables (x_1 – proactive personality, x_2 – role breadth self-efficacy, x_3 – job autonomy, x_4 – co-workers trust, x_5 – supportive supervision, x_6 – flexible role orientation, x_7 – gender, x_8 – age, x_9 – education, x_{10} – firm tenure, x_{11} – team tenure) and ε is the error term.

To test the significance of the regression we conducted a test t on each parameter. Taskwork shared mental models were found to have a significant and positive effect on PPS with a p-value of 0.062, thereby supporting Hypothesis 4 (Figure 3.3).

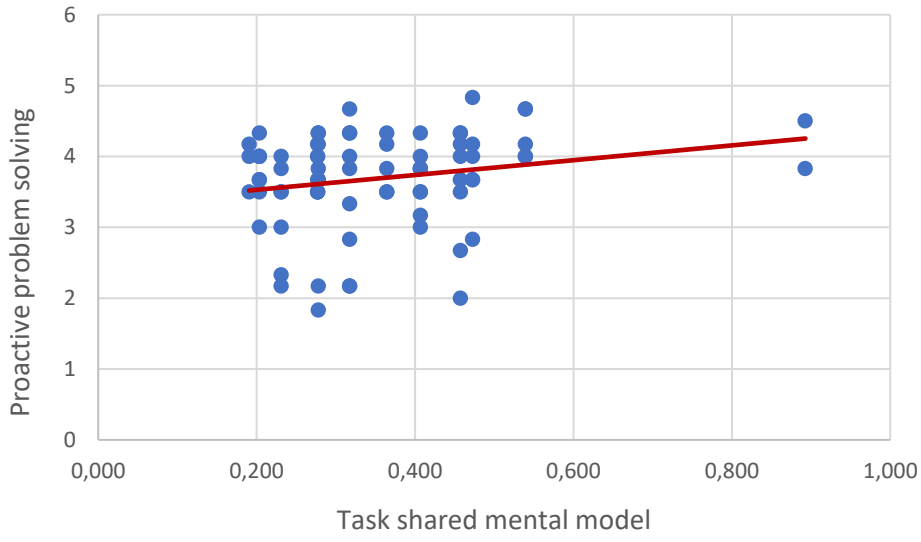

***Figure 3.3**: The scatter plot of the relationship between PPS and task SMM. Graph developed by the author via Excel*

Other relevant results were the positive and significant effects of proactive personality and role breadth self-efficacy (p = 0.097 and p = 0.022, respectively). All other controls showed very high p-values, accepting the null hypotheses that they are not significant variables for the model.

The second regression was about proactive idea implementation, predicted by teamwork shared mental models and all the control variables:

$$\eta_3 = -1.2 - 0.412\xi_2 + 0.115x_1 + 0.16x_2 - 0.102x_3 + 0.063x_4 - 0.021x_5 + 0.136x_6 + 0.006x_7 + 0.001x_8 + 0.00163 - 0.323x_{10} + 0.115x_{11} + \varepsilon$$

where η_3 is PII, ξ_2 is teamwork SMM, x_i (i = 1, 2, ...11) are the control variables and ε is the error term. The test t showed that there is no significant effect between teamwork SMM and PII, thus not supporting Hypothesis 6. Figure 3.4 clearly highlights the absence of any relationship because it is impossible to draw a regression line and points are much dispersed.

***Figure 3.4**: The scatter plot of the relationship between PII and team SMM. Graph developed by the author via Excel*

Among the control variables, the only significant effects were registered with role breadth self-efficacy and firm tenure (p = 0.054 and p = 0.014, respectively); all other controls were not relevant to explain PII behaviour.

A final regression was run on team effectiveness, where we excluded all control variables to simplify the analysis and limit problems due to the small dimension of the statistical sample. Along with measuring the independent effect of all our dependent variables, we also measured how the interactions between PPS and taskwork SMM and PII and teamwork SMM influenced team performance:

$$\eta_1 = 3.896 + 0.173\,\eta_2 + 0.2\eta_3 + 3.172\xi_1 - 4.176\xi_2 - 0.528\eta_2 \times \xi_1 - 0.076\eta_3 \times \xi_2 + \varepsilon$$

where η are the manifest endogenous variables (η_1 – team effectiveness, η_2 – PPS, η_3 – PII), ξ are the manifest exogenous variables (ξ_1 – taskwork SMM, ξ_2 – teamwork SMM) and ε is the error term.

To test the significance of the regression we conducted a test t on each parameter. PPS and PII were found not to be correlated significantly with team effectiveness, therefore not supporting Hypotheses 3 and 5. Hypothesis 1 too, which posited taskwork SMM had a positive direct effect on routine performance, was not confirmed. Instead, a strong and significant effect between teamwork SMM and team effectiveness was registered (p = 0.000), although it was negative (Figure 3.5), thus only partially supporting Hypothesis 2.

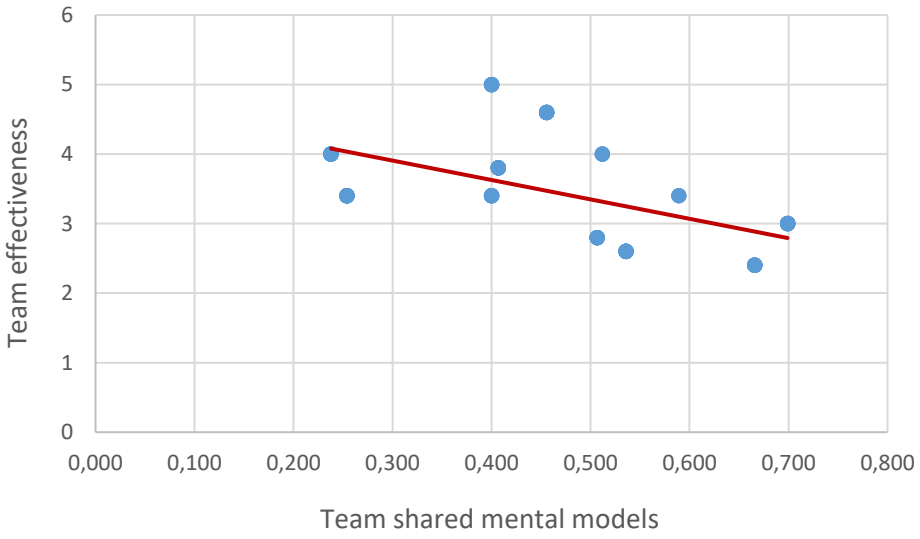

***Figure 3.5**: The scatter plot of the relationship between team effectiveness and team SMM. Graph developed by the author via Excel*

Finally, the indirect effect of shared mental models on team effectiveness was calculated multiplying the effect of the proactive behaviour on team effectiveness by the effect of the correspondent mental model similarity on team effectiveness. None of these two interactions revealed to be significant, hence Hypotheses 4 and 6 are not supported in this sense.

Appendix B reports detailed tables of the OLS regressions estimates, whereas Table 3.3 summarizes the statistics that depict the goodness of fit of these three models.

***Table 3.3**: Goodness of fit statistics of the multiple regression models.*
Table developed by the author via the R software

		Dependent variable		
		PPS	PII	TEAM EFFECTIVENESS
Goodness of fit statistics	Residual standard error	0.632	0.501	0.653
	Multiple R-squared	0.266	0.365	0.331
	Adjusted R-squared	0.122	0.24	0.275
	F statistic	1.845	2.919	5.862
	P-value	0.060	0.003	$5.24*e^{-05}$

All multiple regressions exhibit similar goodness of fit values. The residual standard error and the R-squared statistics confirm that they all explain only a relatively small amount of the variance of their dependent variable, which is in line with the results above that supported only two out of six hypotheses. Something important to understand the dependent variables is still missing and probably the small dimension of the sample aggravated the issue. Nonetheless, the F statistics and the correspondent p-values demonstrate that all three models provide significant results and that they are a better fit for the data than regressions with only the intercept and no independent variables.

3.3.2 Robustness checks

We performed two robustness checks on the obtained results. The first is about showing that using a different measurement for the construct of PPS still supports Hypothesis 4. In particular, we ran an OLS multiple regression with the same predictors (taskwork SMM and all control variables), but substituting the average value obtained from the five point Likert scale with the value that the construct assumes when considering the vignette-based question. Respondents had to analyse a scenario specifically designed for their manufacturing context on which they had to use their problem solving skills: a machinery or equipment is producing defective or non-compliant parts because of a particular problem; the supervisor stresses the importance to

quickly solve the situation, get back to the normal production pace and reduce scraps to maximize quality and recoup the unsatisfied demand. Against this background, they were asked to select one or more actions that they would have more likely taken in this kind of situation. They had a list of six different behavioural responses to choose from, which included not only common strategies that individuals usually engage in (like "Produce more parts to compensate for the defective ones" or "Temporarily solve the problem to minimize the damages caused by the production stop"), but also less common and more proactive actions (such as "Try to solve the problem so that it never happens again" or "Involve other team members to find new technical solutions to solve the problem"). The first type of responses were given a score of 0 in terms of proactive problem solving capabilities, while the second category of actions received 1 point. The final score for the construct value was simply the sum of the points accumulated with the chosen behaviours.

The OLS multiple regression with these PPS values still confirms that taskwork SMM have a positive and significant effect with proactive problem solving (p = 0.075), even showing a slightly greater effect with a coefficient of 1.815. This confirms the robustness of our measurements on this type of behaviour. However, role breadth self-efficacy loses the previously found significance, while team tenure exhibits a small positive effect on PPS at the 90% level of significance (p = 0.069).

Finally, all three original models were run a second time excluding all predictors at the aggregate level of the team, namely both types of shared mental models, and calculating level 1 variables at the individual level rather than considering their average at the team level. This to verify that including level 2 variables was a good addition to the models. Therefore, we conducted an Analysis of Variance (ANOVA) for each model, confronting the regression at the individual level with that at the aggregate level. Both in the case of the two PII and the two team effectiveness regressions the F statistic accepted the null hypothesis (p-values were both much higher than 0.1), hence stating that there was no significant difference between the outputs of the two models. For these reason, it is reasonable to maintain the original models, as the goodness of fit values are slightly better.

As far as what concerns the confrontation of the PPS models, the ANOVA test rejected the null hypothesis at the 90% level of significance (p = 0.062), thereby stating that one model was better than the other. Again, the model that included also the variables at the aggregate level showed better fit statistics (RSE_a = 0.633 vs RSE_i = 0.646; multiple $R\text{-squared}_a$ = 0.266 vs $R\text{-squared}_i$ = 0.223; p_a = 0.06 vs p_i = 0.116, where the subscript *a* indicates aggregate level and the subscript *i* indicates individual level). This means that it explains more variance of the

dependent variable and predictors are better because the average error is smaller. Therefore we can conclude that it is more appropriate.

3.4 Theoretical implications

This empirical study contributes to shed some light on the relatively unexplored topic of shared mental models as antecedents of proactive behaviours. Despite not all hypotheses formulated in the theoretical model were confirmed, two main results emerged. First, we found a significant and positive relationship between taskwork SMM and PPS. Team members interact dynamically, interdependently and adaptively toward a common and valued objective on a daily basis. Each have specific roles, functions or tasks to perform assigned, but that also require consistent and coherent coordination with those of the other teammates. Literature has already highlighted the importance of sharing a common knowledge structure, a mental model, about them to allow team members to interact with each other and the environment (Cannon-Bowers, Salas and Converse, 1993; Mathieu et al., 2000). Here, in particular, we found evidence that sharing a mental model about task-related features of the working activity helps in developing proactive problem solving behaviours in team members, a specific form of interaction.

Taskwork mental models refer to those cognitive structures whose content is about equipment and job tasks, namely: the functioning and limitations of machinery, tools and technology; the dynamics and control of these equipment and how they interact with other teammates inputs; task demands and how to accomplish them, what information are needed, what are likely strategies or potential failures; environmental circumstances and critical constraints and how they can affect the team's actions. When team members have similar or overlapping knowledge in these domains, they are sharing a taskwork mental model. It is easy to understand this is more likely to happen when task procedures are highly standardized, which is exactly a feature of both manufacturing firms of this thesis.

We demonstrated that this cognitive similarity has a positive effect on proactive behaviours, in particular on problem solving skills. Indeed, individuals that share taskwork mental models are able to interpret and analyse the routine or the task in a similar fashion and anticipate other teammates reasoning and actions. This allows them to identify common solutions or strategies to emergencies and tacitly agree on what are the best tools and equipment to utilize in every specific situation.

Most importantly, they are more stimulated to engage in self-starting activities or implement non-standard ways to solve recurrent problems, since they acknowledge that teammates may have the same ideas in mind or they are more inclined to embrace and accept the proposed changes (Furlan, Galeazzo and Paggiaro, 2019). This translates into a context that fosters opinion sharing and the growth and development of employees' problem solving capabilities, of people willing to go deep into understanding what caused the problem to find definitive solutions.

Team mental models, instead, refer to the dynamics of interaction and communication of team members during their working activities, which seem to have more impact on innovative behaviours rather than on problem solving capabilities. Indeed, literature has shown that they are more connected with the implementation of new ideas or approaches to the workplace (West, 1998; Axtell, 2008), as team components feel the success of the group also depends on their ability to improve. Problem solving skills are more likely to be connected to individual capabilities and behaviours than to socially constructed interactions.

A second significant relationship emerged between teamwork SMM and team effectiveness. Because of the highly interactive and interdependent nature of team activities, it is fundamental to share a mental model about team-related features of the working activities. This means developing a common understanding on: roles and responsibilities, not only of oneself but also of other teammates; information flows and communication channels; interaction patterns and role interdependencies, meaning what is each member contribution, when to change behaviour to the needs of the team, when to ask for support or give help to an overloaded member; team-specific knowledge of teammates attitudes, skills, capabilities and preferences. Overall, scholars agree that such cognitive structure is crucial for team effectiveness because it allows team members to tailor their behaviour in accordance with what they expect their teammates are going to do or need (Mathieu et al., 2000). The more team members share a similar knowledge about one another, and the more accurate that information is, the more team decision making improves in terms of quality and speed. This is especially true in case of unexpected emergencies, high stress situations or extraordinary problems where the time to communicate and elaborate strategies is low or absent and team members need to rely on a solid pre-existing knowledge on collective procedures to perform well.

Nevertheless, we found the effect of sharing a teamwork mental model on team performance to be strong and negative. Following Cannon-Bowers et al. (1993) and Kellermanns (2008), we can interpret this result by stating that shared mental models can become a liability if the team relies too much on them. Two similar pathologies that may manifest in these situations are

groupthink and joint myopia. The former was first introduced by Janis (1971) and defined as a mode of thinking cohesive groups have that tends to override realistic appraisal and consideration of alternative courses of action. In teams where groupthink is very dominant, decisions are based on social conformity and members adopt a soft line of criticism, even towards themselves, to seek complete concurrence on every important issue. Conflicts are avoided, deviant thoughts are ignored, warnings and negative feedbacks are discounted in a continuous attempt to maintain unity and unanimity. These circumstances lead to a single-minded team view, as the uniqueness of the individual contribution and opinion is lost. Creativity is also stifled because the diverse perspectives that foster discussion and innovation are suppressed by members' will to stick to their assumptions.

The second pathology is thoroughly described by Knudsen and Srikanth (2014). Although it is a similar concept to groupthink, it refers in particular to the action of searching for new opportunities, optimal choices or better alternatives by multiple agents. This activity is affected by joint myopia when individuals narrow their search space to take into account others' preferences, in order to find a solution that is mutually beneficial. The more a team shares mental models about team members' tendencies, attitudes and preferences, the more they are likely to redirect their efforts in finding an acceptable choice that satisfies the group, rather than looking for the optimal one through the evaluation of different opinions and perspectives. Once they identify a jointly beneficial option, they neglect exploration of other potentially better alternatives. Consequently, team effectiveness can be undermined and routine continuous improvement can stop.

In line with literature's findings, we registered contrasting results, since taskwork mental models did not show any significant relationship with team effectiveness. Despite we expected task SMM to have a direct and positive effect on routine performance through an improvement of team processes (such as strategy formation and better coordination in performing tasks in a similar way), there was no correspondence in the statistical analysis. However, following Mathieu et al. (2005) reasoning, we partially attribute this finding to the low number of teams sampled and the relatively low statistical power of the analysis. Still, the effect would have been positive, in contrast with team SMM, because this type of mental model is likely to be less subjected to groupthink and joint myopia. Indeed, teamwork mental models are inherently characterized by interaction, communication and coordination patterns; these makes them weaker to groupthink dominance, whose objective is to stifle all those opinions and connections superfluous to the main team view. Instead, the interactions that characterize taskwork SMM refer to how team members manage tools, equipment and machinery or how they approach task

procedures and internal or external contingencies, clearly less prone to similar mental model deviances.

It is therefore necessary to reach a delicate level of mental model degree of similarity: too little impedes coordination and favours frequent conflicts, hindering routine effectiveness; too much stifles innovation and may allow incorrect or imprecise decisions to be reinforced and remain unchallenged. Organizations should strive to find a balance by improving their training of team members. For example, they should provide information about each member role and responsibility, as well as specific instructions for the procedures, equipment and system utilized. They can also train leaders and supervisors to instil the right mental models in their subordinates by articulating their own views of task and teamwork, encouraging them to follow his/her advice and, most importantly, leading by example. Moreover, firms should develop feedback mechanisms to avoid confusion on how to perform team tasks and to improve the accuracy of the mental models. Finally, they should promote the agreement on certain norms of confrontation that establish ground rules for what is acceptable, what is encouraged and what are potential sanctions for violations. These efforts will help in fighting groupthink dominance and joint myopia, while, at the same time, preventing conflicts and fostering exchange of opinions.

CONCLUSIONS

This thesis draws on the consideration that current operations management and operational excellence literature rarely address how much employees' proactivity is a crucial fuel for every continuous improvement initiative. The lean management system is a clear example of its importance, since one of its fundamental principle, "Pursue perfection", and the ultimate success of any lean transformation process, rely on people's proactive behaviours.

Hence, we posited that proactive behaviours should have a direct positive impact on team effectiveness, in particular during organizational routines. We also asked ourselves whether working in teams with similar mental models could enhance proactivity. We developed the hypotheses that shared mental models had a direct effect on team performance as well as an indirect effect, through the improvement of employees' proactive behaviours.

Starting from an in-depth review of operations management, organizational behaviour and applied psychology, we built a theoretical model that linked all these constructs, identifying two types of shared mental models (taskwork and teamwork mental models), respectively thought to be the antecedents of two different types of proactive behaviours (proactive problem solving and proactive idea implementation).

To verify these hypotheses we administered a survey to 77 operators and 12 team leaders from 12 teams belonging to two Italian manufacturing firms. The results of the questionnaires were run through different OLS multiple regressions. We found a direct positive effect of taskwork SMM on PPS: because teammates interpret problems and situations in a common way, they reach the same conclusions about procedures and right use of machinery and equipment and are stimulated to implement nonstandard solutions to improve the workplace. Moreover, teamwork SMM exhibited a strong and negative effect on team performance: mental model similarity may indeed become a liability when the cohesiveness of cognitive structures exceeds into groupthink or joint myopia. These hamper any consideration of alternative options and suppress the uniqueness of each member contribution in order to reach concurrence on every issue. We did not find any significant empirical evidence supporting the other hypotheses formulated before.

This research has contributed to current relevant literature offering another study on the relationship between shared mental model and proactivity and their impact on team organizational routine effectiveness. However, it suffered from some limitations. One serious issue was about the dimension of the sample. 77 observations resulted not sufficient to implement a more articulated statistical model, which could have highlighted other important correlations, as well as explained more variance of the dependent variables. Future studies

should aim to gather more operators' responses and develop structural equation models, a multivariate statistical technique that is more suitable to analyse such complex theoretical backgrounds with several related constructs of interest. Moreover, even if we took some precautions, surveys may suffer from social desirability biases, the individuals' tendency to overreport engaging in socially desirable behaviours and underreport socially undesirable behaviours. Using third parties, such as supervisors and team leaders in our case, may help mitigate this problem. However, they in turn may be subjected to the impression management bias (overreporting subordinates proactivity to better self-present themselves) or the observational bias (employees may behave more proactively under the leader's supervision). Future research could focus on laboratory experiments to solve such problems, if they are likely to alter the study's results.

Despite some hypotheses were not supported, we still believe shared cognition in teams is a good explanatory mechanism of team performance. Literature has demonstrated many times that effective teams have similar or compatible knowledge that they use to guide their behaviours; hence, understanding shared mental models within teams can serve as a predictor of the team's likely effectiveness and it can help practitioners to diagnose a team's problems and provide insights into how to solve them. Furthermore, proactivity remains a relevant resource for pursuing any continuous improvement initiative, so finding more evidence for a connection between these two elements may help any organization that strives for perfection. Following this line of reasoning, it will be interesting delving deeper into these topics in the future.

APPENDIX A

***Table A.1**: Varimax rotation of the matrix of factor loadings. Table developed by the author via the SPSS software*

	Component										
	1	2	3	4	5	6	7	8	9	10	11
TEAM EFFECTIVENESS				,714							
V5				,668						,355	
V6				,806							
V7				,911							
V9											,770
PPS			,760								
V13			,717								
V14			,696								
V15			,795								
V17			,676		,410						
V18			,475								
PII					,570						
V21					,664						
V22					,620						
PROACTIVE PERSONALITY									,856		
V28					,354				,463	,377	
V29									,776		
ROLE BREADTH SELF-EFFICACY					,433		,482				
V31							,832				
V32							,650				
V34					,623						
V35					,724						
JOB AUTONOMY	,774										
V37	,760									-,359	
V38	,814										
V39	,771										
V40	,741										
V41	,663									,432	
COWORKER TRUST								,786			
V43				,383				,607			
V44								,695			
SUPPORTIVE SUPERVISION		,828									
V47		,805									
V48		,809									
V49		,896									
FLEXIBLE ROLE ORIENTATION						,483	-,396				
V51						,602					
V53						,680					
V54						,644					

Table A.1 shows the output of the principal component analysis, in particular the matrix of factor loadings extracted with a *varimax* rotation (less than 90 degrees) of the dataset, because it is the cleanest one and it is easily interpretable. Correlations lower than 0,35 are not visible, as they were retained not significant. Moreover, all the problematic items identified through the preliminary statistical analysis and the initial PCA (described in section 3.2.1, 3.2.2 and 3.2.3) are excluded.

It is clear that almost all theoretical constructs correspond to one single principal component and all correlations are very strong. Where cross-loadings exist, they are usually much lower than the main factor loading and therefore can be neglected. However, there are some exceptions. Item V9 has a high correlation with component 11 and the construct of role breadth self-efficacy is not aligned within the same component. Knowing that a perfect matrix cannot be generated, we eventually decided to maintain all these items and bring them back to their main constructs (V9 under component 4 with team effectiveness, V34 and V35 under component 7 role breadth self-efficacy). Indeed, theoretically speaking, none of those cross-loadings makes sense. For example, V34 and V35 under role breadth self-efficacy cannot belong also to the construct of PII because the survey was specifically designed to not make them related and literature clearly distinguishes these two constructs with different definitions.

APPENDIX B

***Table B.1**: OLS regression with PPS as the dependent variable.*
Table developed by the author via the R software

	ESTIMATE	STANDARD ERROR	P-VALUE
ORGANIZATIONAL LEVEL			
Task shared mental model	1.661	0.874	0.062 .
INDIVIDUAL LEVEL			
(Intercept)	0.874	0.914	0.343
Proactive personality	0.173	0.103	0.097 .
Role breadth self-efficacy	0.249	0.106	0.022 *
Job autonomy	-0.133	0.088	0.135
Co-workers trust	0.048	0.086	0.583
Supportive supervision	-0.023	0.079	0.776
Flexible role orientation	0.201	0.122	0.103
Gender	0.131	0.204	0.522
Age	0.009	0.010	0.382
Education	0.071	0.104	0.497
Firm tenure	-0.013	0.164	0.939
Team tenure	0.006	0.151	0.967

Notes: Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

***Table B.2**: OLS regression with PII as the dependent variable.*
Table developed by the author via the R software

	ESTIMATE	STANDARD ERROR	P-VALUE
ORGANIZATIONAL LEVEL			
Team shared mental model	-0.412	0.578	0.479
INDIVIDUAL LEVEL			
(Intercept)	-1.199	0.695	0.090 .
Proactive personality	0.115	0.081	0.160
Role breadth self-efficacy	0.160	0.082	0.054 .
Job autonomy	0.102	0.063	0.111
Co-workers trust	-0.063	0.068	0.359
Supportive supervision	0.021	0.063	0.738
Flexible role orientation	0.136	0.092	0.147
Gender	0.006	0.146	0.965
Age	0.001	0.007	0.920
Education	0.063	0.082	0.445
Firm tenure	0.323	0.128	0.014 *
Team tenure	-0.115	0.113	0.314

Notes: Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

***Table B.3**: OLS regression with team effectiveness as the dependent variable.*
Table developed by the author via the R software

	ESTIMATE	STANDARD ERROR	P-VALUE
ORGANIZATIONAL LEVEL			
Task shared mental model	3.172	4.217	0.454
Team shared mental model	-4.176	1.114	0.000 ***
INDIVIDUAL LEVEL			
(Intercept)	3.896	1.590	0.017 *
PPS	0.173	0.408	0.673
PII	0.200	0.593	0.737
PPS*Task SMM	-0.528	1.083	0.628
PII*Team SMM	-0.076	1.429	0.958

Notes: Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

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