# The Lean Strategies: A tale of user-driven innovation processes

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## ABSTRACT

Since 1978 several Lean Strategies have been defined and nowadays companies are increasing the adoption of them. However, there are still several practitioners that face some issues in understanding which practice is most suitable for their context and how to apply the practice in the correct way.

In order to help practitioners to select which practice to adopt, in this work we provide a systematic comparison of the most common Lean Strategies based on a structured literature review. We compared the process models of the six most common Lean Strategies including: Lean Design, Lean Innovation, Lean Manufacturing, Lean Thinking, Lean SixSigma and Lean Startup.

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## 1 INTRODUCTION

The term "Lean" was coined by Womack [2] in the late 1980s, in order to describe Toyota's business and to optimize production processes [4]. The term is related to maximize customer value while minimizing any kind of waste inside the process or removing any needless or redundant activity and creating more customers value with fewer resources [5].

Lean strategy allowed to revolutionize production processes first in the automotive industry [5], and then it have become important in the context of general management, and other domains such as IT [5].Several Lean Strategies have been identified since Womack proposal of Lean Manufacturing in 1978 [2]: Lean Design [16], Lean Innovation [3], Lean Thinking [3], Lean SixSigma [13] and Lean Startup[6]. Many companies are adopting Lean Strategies and researcher also focused in deep on each of them. However, there is still a general misunderstanding on the purpose of the different strategies and companies commonly are not able to understand which strategy is better to apply in their context. At the best of our knowledge, only one work compared two strategies (Lean Startup and Design Thinking) [5]. This could create confusion among the practitioners when they evaluate which strategy adopted and which is the most suitable for their specific purposes.


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For this purpose, in this paper we aim at supporting practitioners in understanding which Lean Strategy is most suitable in the different context. Therefore, the goal of this paper is to present a structured comparison of the lean Strategies, so as to support practitioners in understanding their commonalities and differences. The Lean Strategies considered in this work are: Lean Design, Lean Innovation, Lean Manufacturing, Lean Thinking, Lean SixSigma and Lean Startup.

Based on this goal, we outlined the following two Research Questions (RQs):

**RQ1**: Which are the purposes of the different Lean Strategies? In this RQ we aim at understand the purpose and the context where the Lean Strategies can be applied. Moreover, we also aim at highlighting their main steps.

**RQ2**: Which are the commonalities and differences of the different Lean Strategies? In this RQ, we focus on comparing the different Lean Strategies, classifying and highlighting commonalities and differences.

The paper is structured to support practitioners to easily compare the strategies, without dealing in complex literature and scientific details, starting from Section 2 where we briefly introduce the history of the Lean approaches. In Section 3 we summarize the Lean strategies making a comparison among them and discussing the contexts where the different strategies are more applicable. Finally, in Section 4 we draw conclusions.

## 2 THE HISTORY OF LEAN STRATEGIES

In this section we introduce the six most popular Lean Strategies and applied in the industry, highlighting their purposes (RQ1), their application contexts and their process models. In Figure 1, we depict the historical evolution of the Lean Strategies.

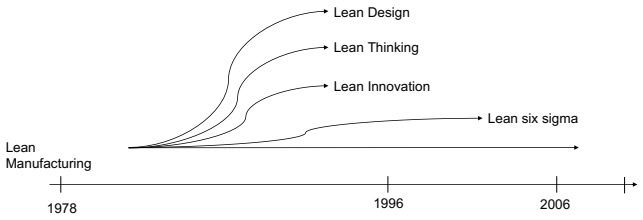


**Figure 1: Comparison among the different Lean strategy**

### 2.1 Lean Manufacturing

For the past decades, *"Lean Manufacturing"* has been the buzzword in this area (manufacturing) and several manufacturing industries have been trying to get *"Lean"*. Lean manufacturing is based on five

principles: value from the customers perspective, identify all the process chain steps, processes flow, pull system, seek the perfection.

Becoming Lean is not as easy as it seems. It requires total dedication from personnel, careful planning, strong leadership and adequate knowledge about the lean manufacturing philosophy, tools and techniques [19].

Toyota and other Japanese companies learned the importance of quality and satisfying their customers in several sectors including automotive, electronics, white goods, and consumer products manufacturing. They also learned the importance of involving their entire workforce in making improvements. Quality and respect for their people became very important for Toyota. The system focused on pinpointing the major sources of waste in human effort, inventory, time to market and manufacturing space to become highly responsive to customer demand while producing world-class quality products in the most efficient and economical manner and cost reduction in particular by eliminating non value added activities, using specific tools (such as JIT, oduction smoothing, setup reduction, etc).

Wastes are categorized as part of the seven wastes: Transport, Inventory, Motion, Waiting, Over-processing, Overproduction, Defects.

All of these wastes have a direct impact on costs, they are all non-value adding operations, that customer would not be happy to pay for and add no value to the product or service provided.

Lean manufacturing strategy contributes for high performance in any organisation. Managers have also been hesitant to adopt lean manufacturing tools and techniques because of some characteristics: inflexible machines, long setup times, and the general difficulty in producing in small batches.

Lean manufacturing combines the ability to reduce costs per unit and dramatically improve quality while at the same time providing an ever-wider range of products and more challenging work [2].

Lean manufacturing has some main goals: waste in human effort waste reduction, wastes related to inventory, time to market and in manufacturing space be properly responsive to customer demand by improving quality efficiently and economically.

Lean manufacturing tools when used appropriately, can help the process industry eliminate waste, maintain better inventory control, improve product quality, and obtain better overall financial and operational control.

## 2.2 Lean Design

Design for Lean was first coined by Womack [3]. It applies the principles of the lean production in order to eliminate waste and non-value activities in processes. Lean Design is based on three perspectives that describe the process: Conversion, Flow, and Value generation [16]. Lean Design allows modeling by the practical application of these three perspectives in the design process. Moreover, this strategy suggest the tools implementation in order to integrate them in the quality improvement of the process. Conversion perspective helps to discover which tasks are needed in a design undertaking. Conversion is not useful for improvement but for management make up the core of it by doing an adequate amount of work, without dealing with unnecessary work and delivering the required business [16].

Flow and Value generation perspectives are in contrast to the conversion model traditional vision, where the emphasis is on obtaining the customers requirements. In this case the design improvement is gave by value reduction in the process and by improving the product performance and reducing defects [16], [17].

**Conversion**. The main principles of Conversion are hierarchical decomposition, control and optimization of decomposed activities. Conversion simply "takes care about what has to be done" and it is structured by means of work breakdown structure, critical path method, organizational and responsibility chart [16].

**Flow**. Flow perspective can be seen as a flow of information, composed by conversion, inspection, moving and waiting in order to elimination of waste, non conversion and time reduction of the activities. Flow is simply related to understand what is unnecessary in the process through a rapid uncertainty reduction, team approach, tool integration and partnering [16]. Moreover, this prospective allows to coordinate the interdependent flows and the integration of design [18]

**Value generation**. Value generation is a process necessary to create value for the customer by means of requirements fulfillment. It aims to eliminate value loss achieved value in relation to best possible value. The main methods are rigorous requirement analysis, systematized flowdown requirements management and their optimization. Value generation means finding the best solution to met customer requirements [16].

## 2.3 Lean Innovation

Lean Innovation was defined by Womack in 1996 [3]. Nowadays this practice is very common in many manufacturing companies around the world. The Lean innovation manager should consider as his main goals in the innovation projects: (1) produced at a cost well below the price the customer is willing to pay; (2) delivered and serviced through a distribution channel that can reach the target market cost effectively.

The Lean Enterprise Institute[1] and Greg Cohen in his book Lean Product Management [9] describes the Lean Innovation as five steps and principles:

(1) **Identify Customer Value**: definition of the value from the customer perspective.
(2) **Map the Value Stream**: identification of the steps that create value focusing on the material and information flow across the system.
(3) **Create Flow**: assemble value-creating steps in a tight sequence to enable value to flow quickly through the system.
(4) **Establish Pull**: as value starts to flow, value is pulled through the system ideally by the customer and at the rate of customer demand ("build to order" is a pull system). This contrasts to most systems, which are push. In a pull system, development signals that capacity has become available and product management then provides the next most important requirement on which to work.
(5) **Seek "Perfection"**: repeat the previous four steps until removed all waste in the system. Perfection is a state that the professionals continue to approach but never actually achieve.

[1] https://www.lean.org

Sehested and Sonnenberg in 2011 [8] reported 3 dimensions to achieving efficiency with lean innovation strategy:

- **Do the right thing.** This aspect helps to not avoid waste using the technical competencies to meet the customers' need, in order to not avoid over and/or under-developing the product. This aspect involves internal and external customers.
- **Do it right.** This aspect helps to plan the work process in an efficient manner. It is also called "value stream"
- **Get better**. This aspect involves a continuously evaluation and improvement of the work as part of the daily routine.

One of the important suggestion provided by Lean Innovation is to eliminate waste in order to improve the product efficiency. One activity could be organizing "waste workshop" where the employees should identify anything that does not create value to the product and to the company and that could led to cause damage to them.

They suggested 7 types of waste the company need to be aware of in an innovation process:

- Definition of market is too broad and imprecise;
- Wrong choices during portfolio process;
- Functionalities the customer doesn't need;
- Information that isn't translated into relevant insights for the solution in question;
- Available and relevant knowledge that isn't shared;
- Working and testing without learning;
- Uncoordinated goals and silo thinking

Seven key principles for lean innovation were reported in [8]:

(1) **Gemba.** Going to gemba means *"going to the place where the truth is found"*. This principle helps companies to understand what happens in the context by experiencing it for yourself before saying how a problem should be solved.
(2) **Front loading.** Front loading can help companies to increase the knowledge level in the early project stages. It also means to allocate more resources coming from the outset, postponing decisions until enough information is available.
(3) **Visual management.** A good visualization can help the company to imagine the possible future situations and solutions and also to manage the work processes.
(4) **Timeboxing.** âĂŸTimeboxingâĂŹ is when you operate with a fixed lead time so the end time for a deliverable is set in stone.
(5) **One-piece flow.** Increasing focus on one-piece flow could give many advantages for the companies. Increasing the concentration means an higher-quality solution and loose less time as possible can lowering costs.
(6) **Takt.** An innovative Takt is the pipeline for a new product. A good Takt has many advantages: Greater predictability in the innovation process and more opportunities to receive feedback in order to support continuous improvements.
(7) **Prototyping.** Prototyping means testing the assumptions in order to iteratively improve your product. Prototyping includes: functional solutions, computer simulations, models and images/graphics.

## 2.4 Lean Thinking

We have seen some different definitions from James P. Womack and Daniel T. Jones [3] who coined the term "Lean Thinking". In 1996 in their book Lean Thinking, they defined "Lean Thinking" as the description of what they had learned in their research about the people who were creating Lean organizations. Their definition was consisting of the following five principles that guided peopleâĂŹs actions:

(1) **Specify Value**. It needs to completely understand what value the customer places upon their products and services, it determines the amount of money the customer is willing to pay for the product and services;
(2) **The Value Stream**. The value stream is the entire flow of a product's life-cycle;
(3) **Flow**. Carefully designed flow across the entire value chain will tend to minimize waste and increase value to the customer.
(4) **Pull**. A pull approach states that we do not make anything until the customer orders it. To achieve this requires great flexibility and very short cycle times of design, production, and delivery of the products and services.
(5) **Perfection**. A lean manufacturer sets his/her targets for perfection and systematically and continuously remove the root causes of poor quality moving towards perfection. This is the key attitude for "going for lean".

Then, according the Lean Lexicon in 2007 Womack and Jones "simplified the five steps": Purpose, Process, People.

In 2014, Daniel T. Jones offers a definition less technocratic: "Lean Thinking and practice are generic versions of the Toyota Production System (TPS) and the Toyota Way management system, substantially different from the previous definitions." Only a month later, Michael Ballé and Daniel Jones define "Lean Thinking" as: "Toyota grounded its management on learning and, over the years, developed a continuous on-the-job learning method based on two pillars: continuous improvement-continuously challenging oneself and learning by continuous small steps-and respect-making our best efforts to understand the obstacles each person encounters, supporting their development and making the best possible use of their abilities". We refer to this as "Lean Thinking".

According to Hines et al. [10], Lean Thinking can be also defined as "a managerial philosophy which enhances the value perceived by the customers, by adding product and/or service features and by continuously removing non value added activities i.e. wastes), which are concealed in any kind of process.

The application of Lean Thinking had an impressive impact both in academic and industrial fields over the last decade. Promoted by a fast diffusion into industry sectors beyond the automotive industry, there has been a significant development and "localization" of the lean concept [11].

Lean Thinking starts with the customer and the definition of value, its principles should be applicable to several processes. It is possible to remove waste from many steps, however, to be truly lean it needs to ensure the flow of value. The elimination of waste represents a huge potential in terms of improvements the key is to: identify both waste and value and develop a knowledge management base.

However there is still a gap in the literature about ways in which Lean Thinking can contribute to environmental outcomes and transform operations to '*sustainable business practice*' defined as business behavior that leads to a net overall increase in the different forms of capital associated with sustainable development.

Lean thinking conduct to continuous improvement of value stream by following the Plan-Do-Check-Act (PDCA) cycle of Lean. The PDCA Cycle is the 4 stage Lean working structure:

- **Plan**. Create a plan for change. Define the steps you need to make the change, and predict the results of that change.
- **Do**. Carry out the plan in a trial or test environment, on a small scale, under controlled conditions.
- **Check**. Examine the results and verify the improvements.
- **Act**.Implement the changes youâĂŹve verified on a broader scale. Update the procedures.

Lean is a way companies need to operate in an ever more competitive global market moving from an old way of thinking to Lean Thinking. This transformation requires a long term perspective and perseverance that will result in an all-encompassing revolution in how companies conduct their business.

## 2.5 Lean SixSigma

Lean SixSigma originated from Lean Manufacturing and has been formally defined in 2006 by Brady and Allen [13]. It is based on statistical analysis. Differently by the other Lean Strategies, Six Sigma uses the formal DMAIC process, breaking down projects into phases. Lean Six Sigma is defined as *"A management approach for problem solving and process improvement based on a combination of the different tools of Six Sigma and Lean Manufacturing"* [2] This strategy combines both Lean and SixSigma approaches in order to statistically measure the defect rate in a system [13]. Six Sigma improves Lean concept providing the tools and know-how to tackle specific problems identified by Lean strategy. The Lean does not explicitly prescribe the culture and infrastructure needed to achieve and sustain results and does not recognize the impact of variation [15].

Lean and Six Sigma strategy can be idealized as a comprehensive methodology where the key elements of both strategies are joined together. Following we report the five main principles in Lean Six Sigma [12]:

(1) **Customer Focus**. The customer is always to be put as the first in the company that implement the idea immediately. Based on it the first process step is defining what "quality" means. Focusing on the customer needs can improve both the business and the products' quality;
(2) **Identify Root Causes**. An unchangeable method can cause problems to the entire process and an efficient root cause identification is necessary to understand them. One approach could be involving interviewing people, making observations, and asking questions inside the company.
(3) **Eliminate Variation**.The company and especially the team should only concentrate on the problem in order to identify how or what generated it and eliminate defects from the process. The company should also eliminate the steps that do not add value for the customer point of view;
(4) **Be Flexible and Thorough**. Many task to do could slow the process efficiency and it is necessary to be proportional to the results the company sees. The team should be motivated to adapt to change. In the beginning and the company have to clarify the benefits;
(5) **Teamwork**. Team and leaders must be trained about the Six Sigma strategy and on communication skills also relate to the communication with the customers.

Lean SixSigma can be considered as a quality management approach with many positive elements to continuous improvement that provides a clear focus on measurable financial returns and leads the way in data-driven decision making for improvement efforts [14].

## 2.6 Lean Startup

Lean Startup is a methodology that helps to innovate and create value for the customer, it provides a scientific approach to creating and managing startups and get a desired product to customers' hands faster.

It gives suggestions regarding how to drive a startup how to steer, when to turn, and when to persevere-and grow a business with maximum acceleration. The term "Lean startup" was conied in IT development for software startup and rose in popularity in 2011 with "The Lean Startup", the book of Ries. This methodology try to test core business assumptions early in the product development process, sometimes even before any product is built at all. The keys steps are track assumptions and learn from the insights gathered during testing with the customer. The build-measure-learn cycle, the core component of Lean Startup methodology, allows to make progress in an iterative way, while getting closer to the solution your customer wants to have. Once the feedback loop has been established as the company's process of producing solutions, the next thing on the agenda is figuring out ways to minimize the total time through the loop.[6]

The Lean Startup process affirms that the one for which there is an actual demand by the users is the most efficient innovation. Or, in other words: waste is represented by the creation of a product or service that nobody needs. This concept is crucial when creating innovations.

The first step is figuring out the problem that needs to be solved and then developing a minimum viable product (MVP)[1] to begin the process of learning as quickly as possible. Once the MVP is established, a startup can work on assess the engine. This will involve measurement and learning and must include actionable metrics that can demonstrate cause and effect question. Since there is no explicit process model for lean startup, we consider the customer development process, which consists of four steps: "customer discovery", "customer validation", "customer creation", and "company building" [22][24].

Lean startup includes the influences and effects of customer development, Agile, software development, Lean management [4], and open source software [6] In particular it could be seen as a variant to Agile, which promotes the identification of risky parts of a software business and provides a minimum viable product (MVP)[1]

[2] http://www.businessdictionary.com/definition/Lean-Six-Sigma.html

to be tested and modified in the next process iterations[23]. Prototyping is a crucial key for shorting time-to-market.[21][25] In Lean startup methodology emerge few important implications such as experimentation, customer feedback, and iterative design over traditional "big design up front" development. Lean startup is just a few years old, but its concepts such as "minimum viable product" and "pivoting" have quickly taken root in start-up world, and business schools already started teaching them.

## 3 COMPARISON OF THE LEAN STRATEGIES

In this Section, we present a detailed comparison of the six Lean strategies considered in this work, so as to answer to our RQ2. We compare the most important and significant aspects of these strategies underlining similarities and differences among them.

We considered the main goals and the specific focus of all methods, the approaches, specific process steps and the target groups.

According to the previous strategies descriptions we found much common points. For example Lean Innovation and Lean Thinking brought their definition directly from Womack [2].

In (Table1), we present a detailed comparison and classification of the different Lean Strategies analyzed.

**Goal.** The common goal of the six Lean Strategies analyzed is improve process and and product quality. However, several differences emerged in the strategies.

*Lean Manufacturing, Thinking and Design* have the common goal of reducing wastes and identify/eliminate no-added-value activities.

*Lean Innovation* has the goal of producing at a cost well below the price the customer is willing to pay.

*Lean six sigma* is focused on continuous improvement, with a data-driven decision for selecting the improvement efforts.

*Lean Innovation*-Manufacturing-*Thinking* propose a list of common Lean principles, later declined from a "specific" point of view, in example Lean Innovation focus on wastes elimination for improving the product efficiency. In particular they identify seven sources of waste. Similarly individuate also seven key principles maybe more specific and tailored on the company context/environment. About the context or applications of Manufacturing and Thinking, they have a broad possibility to be used in several contexts: automotive, electronics, consumer products and so on.

*Manufacturing-Thinking and Innovation* derived from the same root (Lean manufacturing), they adapted their principles to the evolving context: from manufacturing to automotive, software etc. In Lean manufacturing wastes are identified from their sources: human behavior, inventory, time to market and so on. Specific tools are used to eliminate wastes: JIT, setup reduction etc. A direct connection between non add-value activities and wastes is identified as "Operation that customer would not happy to pay for the provided product or service".

Lean Thinking could be defined according to three of four main definitions derived from the Toyota culture. The application of Lean Thinking include also a managerial philosophy that enhance the value perceived from the customer adding product or services and removing wastes. Specific tools or iterative procedures are identified and used for waste elimination process. Lean Thinking reaches both Academic and Industrial worlds.

**Similarities.** In this section we describe the found similarities among the closer studied strategies. Lean Manufacturing, Lean Innovation and Lean Thinking have several similarities. They all extend the Lean principles adding or removing some principles. Likewise, these strategies present a clear identification and categorization of wastes and activities for added/no-added value, in these strategies both aspects are reformulated and maybe adapted. Lean Innovation, Lean Manufacturing and Lean Thinking also include the usage of an iterative approach, the first consists in application of reduced set of lean principles, the second of a continuous improvement-iterative learning process, the third of plan-do-check-act process. Also lean startup use an iteration process a learning process: Build-measure-Learn.

Lean Manufacturing and Lean Innovation categorized wasted in seven categories but each strategy made this process from a specific point of view. About the context and application fields, Manufacturing and Thinking have a broad possibility to be used in several contexts: automotive, electronics, consumer products and so on. For Lean Design and Six sigma is unclear in which context they can specifically "work". For Lean startup the application field depends by the startup typology, so it can be used more or less in all fields. Lean Innovation and Lean Thinking took their definition directly from [2] but Lean Thinking is characterized from more than one definition that represents the evolution of some aspects. Among all of these six strategies the focus is common but the used approach are various without fixed rules or activities. Manufacturing and Thinking in addition to the same root, that is manufacturing, have the same application field that has common origins. All strategies have as a target group the customer, because all of them aim to give more value to the customer

**Differences.** Although Lean Manufacturing, Innovation, and Thinking have more similarities, Lean Innovation presents a different goal: "Produced at a cost well below the price the customer is willing to pay. Delivered and serviced through a distribution channel that can reach the target market cost effectively".

As it can be seen in the final table where we summarize the main aspects of each strategy the main differences are among the major group that includes "Manufacturing-Innovation-Thinking" e the rest considering each strategy as "without commonalities with others". Only Lean manufacturing and Thinking even if they born in a manufacturing context evolved their application domain toward automotive, electronics, software. We found many sources of information for almost all strategies except for Lean Design maybe is a niche strategy used specific context or companies. Design presents a very different steps process: Conversion-Flow Value generation for eliminate wastes and continuous improvement.

## 4 CONCLUSION

In this work we present a detailed comparison of six Lean Strategies: Lean Manufacturing, Lean Design, Lean Innovation, Lean Thinking, Six Sigma and Lean Startup.

We first draw an historical overview of the strategies, then we introduce and finally compare them.

Results of this work will support practitioners in quickly understand differences and commonalities of the existing practices, without dealing in complex scientific literature details.

**Table 1: Lean Strategies Comparison**

| What | Lean Strategy | | | | | |
|---|---|---|---|---|---|---|
| | Design | Innovation | Manufacturing | Thinking | SixSigma | Startup |
| **Goal** | Eliminate waste and non-value activities | Produced at a cost well below the price the customer is willing to pay. Delivered and serviced through a distribution channel that can reach the target market cost effectively | to reduce the waste in human effort, inventory, time to market and manufacturing space to become highly responsive to customer demand while producing world-class quality products in the most efficient and economical manner | reduce or eliminate not add value activities and wastes in general | continuous improvement leads the way in data-driven decision making for improvement efforts | Innovation |
| **Approach** | rigorous requirement analysis, systematized flowdown requirements management and their optimization | Identification of five steps and principles | Lean operations management design approach | comprehensive methodology where the key elements of both strategies are joined together | opportunities identification and defects elimination based on customers needs; deliver high-quality services; deliver high-quality services; focus on data-driven decisions and on comprehensive set of quality tools in order to effective problem solving. | user-centered (continuous feedback-loop) |
| **Application** | - | | automotive, electronics, consumer products and so on | automotive, electronics, consumer products and so on | - | all fields |
| **Context** | - | Manufacturing | Manufacturing | Manufacturing | - | Startups |
| **Iteration** | - | Identify customer value-Map the value stream -Create Flow-Establish Pull-Seek perfection | continuous on-the-job learning method based on two pillars: continuous improvement-continuously challenging oneself and learning by continuous small-steps and respect-making | e Plan-Do-Check-Act (PDCA) cycle of Lean | - | Build-Measure-Learn cycle |
| **Target Group** | Customer | Customer | Customer | Customer | Customer | Customer |

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