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# Lean Production and industry 4.0 Technologies: Link and interactions

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**Abstract.** In current economic environment, two paradigms are sustaining the industrial performance: Lean production and industry 4.0 technologies. Whatever business the companies run they have to consider the benefits of Lean and the benefits of the arrival of new technologies of industry 4.0. The remaining question is how to consider these two paradigms in successful association to achieve high performance, reliable products and relevant supply chains. This paper suggests a first attempt to combine those two concepts. Previous works have highlighted the necessity of using both misleading modeling adequate approach of implementation. After browsing the existing studies related to this subject, this contribution shows the interactions that may co-exist between Lean and industry 4.0 technologies. The methodology is based on different analysis with accurate association of each technology and its ability to sustain Lean production approaches. Bilateral model can rise providing interesting insights to help managers in their transformation strategy often covering Lean and industry 4.0 technologies implementation.

**Keywords:** Lean Production, Industry 4.0, Technologies of industry 4.0.

## 1 Introduction

To improve the performance of industrial systems and boost the production efficiency, an increasing number of companies around the world are undertaking Lean production transformation from workshops to whole enterprise and even global supply chain. Lean is considered as a methodical approach to organize and optimize the production flow aiming at realizing a continuous value stream to increase the quality and improve the reactivity while reducing the wastes and non-value-added activities. It is a mature system used for more than 60 years in Japan and more than 30 years in Europe. Concurrently, Industry 4.0 is a global concept aiming to design and create the enterprise of the future and smart factories. It focusses on the technology-driven vision combining the physical world and the cyber world through specific web and digital technologies [1].

## 2 Literature review

Industry 4.0 grasps the attention of many researchers and practitioners [2], [3],[4],[5]. Indeed, there is an urgent necessity to clarify its implementation because no structured and well-defined model or method yet exist [6], [7], [8]. Few attempts have defined standards useful to identify the scope and the main fundamentals. In [9] authors remind the first community efforts to standardize the comprehension, namely Reference Architecture Model for Industry 4.0 (RAMI 4.0) that has been introduced by the German Electrical and Electronic Manufacturers' Association [10]. RAMI 4.0 introduces a three-dimensional coordinate system that describes all crucial components of Industry 4.0. Within this system, complex and complicated interrelations can be decomposed into subsystems, clusters, or modules [11].

Both approaches (Figure 1) contribute to close similar targets. Lean production aims to reduce time, increase quality avoiding defect products and decrease costs while maintaining safety target and worker motivation.







		Lean Production		Industrie 4.0
	Approach	holistic (human + technology + organisation)	↔	technology driven
	Philosophy	people development + problem solving	↔	feasibility, (self) optimisation
	Foundation	stability and standardisation	+	interconnectivity, adaptivity
	Control principle	flow, pull, FIFO	+	dynamic, depending on current situation
	Improvement + problem solving	proactive → standard, abnormality → reactive	+	data based learning → predictive
	Information acquisition	real place, real material („Go and See“)	+	problem specific data provision, „real time“

Figure 1 Lean Production and Industry 4.0 comparison (Enke, 2018)

Industry 4.0 adds elements of individualization, new business models and connected systems [12]. A literature review shows that either Lean production is impacting the evolution of Industry 4.0 and Industry 4.0 technologies are supporting the evolution of Lean Production. In [6] authors highlight that both paradigms have often been considered as separate subjects. Some authors catch the idea to associate both but in unilateral analysis with the necessity of Lean Production as a requirement for Industry 4.0.

Figure 2 shows the possible gain if Industry 4.0 is implemented after the application of Lean inducing new long-term increase in productivity with no saturation point (as it can be seen in case where Lean is implemented alone disregarding the offered possibilities by Industry 4.0).

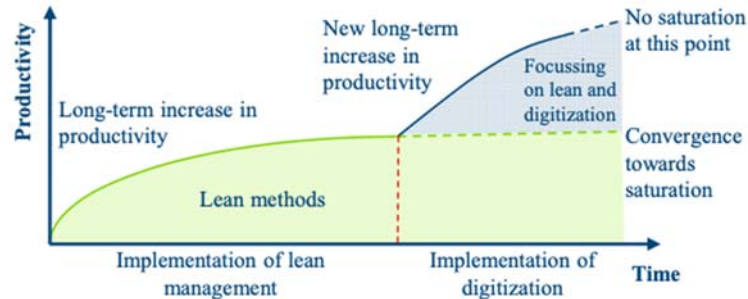


Figure 2. Productivity improvement when digitization follows Lean (Prinz et al., 2018)

In [6] author has led a study on Norway companies to extract the linkage between Lean implementation and the evolution of Industry 4.0 maturity. Figure 3 outlines that, in the timeline representing the sequential implementation of new improvement axes, it is of utmost importance to apply Lean techniques as pre requisites of Industry 4.0 implementation to ensure the manual routines and quality sustainment.

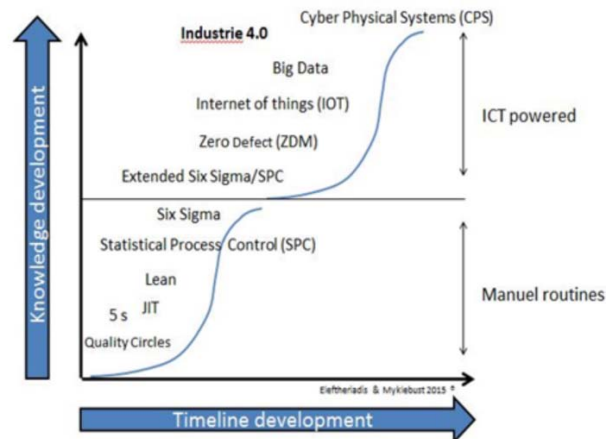


Figure 3. Lean and industry 4.0 positioning in timeline development (Eleftheriadis, 2018).

Satoglu in [13] considers the combination of both approaches and suggest that *“lean and industry 4.0 are not mutually exclusive but can be combined however the combination is yet very primitive with direct dual combination of effects without global model”*. Industry 4.0 supports factor to implement Lean. Lean activities should be well performed before automatization and connection. This is interesting to state that Industry 4.0 does not substitute to mismanagement and weak organized manufacturing. It is worth to denote that exclusive

link with unilateral analysis is not enough anymore. Mayr in [14] evoke very recently the possible conjunction between both research axes. Author in [15] reviews some examples of leading Lean and Industry 4.0 in conjunction. Author in [16] relates relevant findings indicating that European manufacturers that aim to adopt higher levels of Industry 4.0 must concurrently implement Lean production as a way to support process improvements. In [18] authors evoke Industry 4.0 technologies as enablers of leaner production. [19] authors treated how to use or leave lean. Lean is pre requisite, this approach is consolidated by very big industrialists as Schneider, Bosch, Faurécia, Dassault who already implemented Lean Production Strategy before committing in the industry 4.0 transformation.

### 3 Methodology

The target of our approach is to thoroughly study the combination between these two paradigms influencing the industrial performance. By Performance, we mean global performance at the level of a factory, or enterprise or even supply chain level. To successfully achieve a performance, which is generally a complex task, deeper analysis has to be led. Different paths (Figure 4) are possible to achieve optimization in factories/enterprises and supply chains. The aim of the study is to browse the existing studies subscribing to path 1 (where industry 4.0 technologies are essential and followed by Lean techniques) and those subscribing to path 2 claiming that Lean is a prerequisite to initiate Industry 4.0 transformation. The developed model will likely follow an incremental model to show gradually the success achievement with clarified steps. The idea is to model the different layers of industry 4.0 technologies implementation and Lean integration led in conjunction.

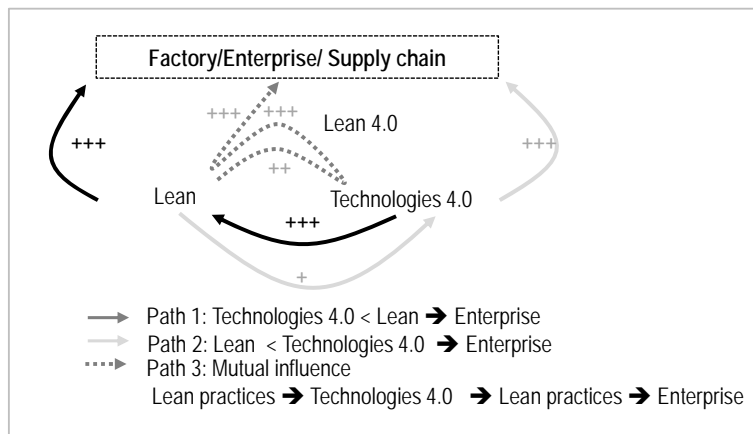


Figure 4. Joint analysis between Lean and industry 4.0 technologies

The work starts with initiated analysis led by the German university in 2017 (figure 5). Technologies can be split into sensors/actuators, cloud computing, bigdata, data analytics, virtual/augmented reality and machine to machine communication. Each one of those technologies is influencing the efficiency of one or many Lean techniques.

	Data Acquisition and Data Processing				Machine to Machine Communication (M2M)		Human-Machine Interaction (HMI)	
	Sensors and Actuators	Cloud Computing	Big Data	Analytics	Vertical integration	Horizontal integration	Virtual Reality	Augmented Reality
5S	+	+	+	+	+	+	++	+++
Kaizen	+	++	+++	+++	+++	+++	+++	+++
Just-in-Time	++	++	+++	+++	+++	++	+	++
Jidoka	+	+++	+++	+++	++	++	+	+
Heijunka	++	++	+++	+++	+++	++	++	+
Standardisation	++	+++	+++	+++	++	++	+++	+++
Takt time	+	+	+++	+++	+++	+++	+	+
Pull flow	++	+	+	+	+++	+++	+	+
Man-machine separation	+	+	+	+	+	+	+++	+++
People and teamwork	+	+	+	+	+	+	+++	+++
Waste reduction	+	+	++	+++	+++	+++	+	+

Figure 5. Industry 4.0 impact on Lean Production system – German study [17]

For instance, Augmented reality is useful to sustain 5S approach, helps to make reliable kaizen and people development. Smart sensors are helpful to support Just in time lean practice. However, we may highlight some critical points to Wagner's study: some of technologies are lacking in this table as Digital twin, Robotics, Internet Of things, 3D printing, AGV,... Other Lean Production practices are missing: Value Stream Mapping, Visual Management, Kanban, SMED.

The target of our study is to lead towards a more exhaustive and deeper analysis (figure 6). Each technology may contribute to different Lean production techniques. This association is of utmost importance to reveal beginning of interactions regarding wider scope of technologies and wider sample of Lean Production practices.

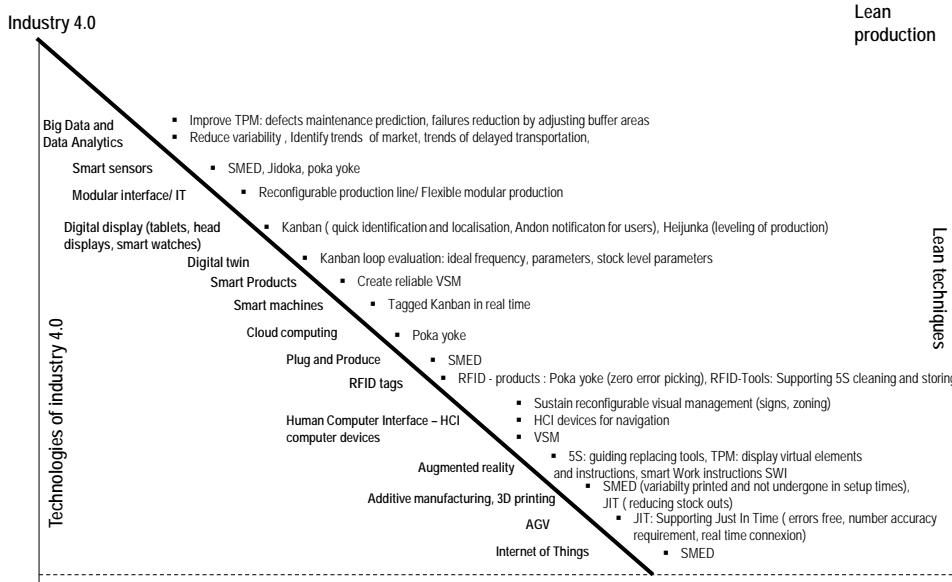


Figure 6. The link between Lean Production and Industry 4.0 technologies

The next step aims at deeply modeling the mutual interactions to perceive the gradual transformation for a company over time. For visualizing the link and interactions, we suggest the following points of interactions. The timeline synoptic provided by figure 7 reveals the intended progress. Different steps have to be undertaken in accordance with literature extensive review, analysis of correlations, use formal modelling and global model formalization considering the different configurations.

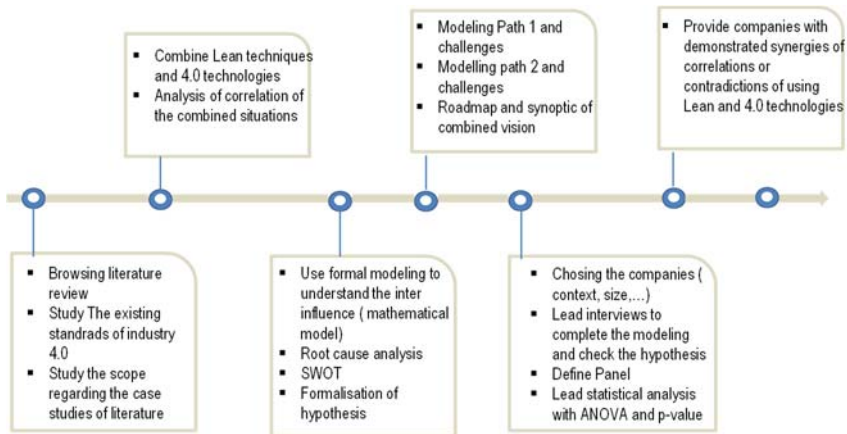


Figure 7. Lean Production and Industry 4.0 interrelations methodology



Once achieved, the model has to be tested and checked by companies. Interviews are also an important pillar to validate the findings and provide global roadmap to the companies expecting to lead industry 4.0 transformation and already engaged in Lean Production conversion. The idea of modularity and incremental integration of Industry 4.0 technologies will be deeply analyzed to federate the proposed model.

#### 4 Perspectives and Conclusion

In near future, a cartography about the challenges, the important requirements and the impacts in path 1 and path 2 configurations will be explored.

The idea is to base the analysis on existing works to improve and identify the cross areas where correlations can be identified in order to provide a global synoptic about industry 4.0 technologies use and Lean Production implementation. Also, we will provide a mapping of the usefulness of the combined model Lean Production 4.0 for companies of our region “Nouvelle Aquitaine” after leading industry 4.0 maturity evaluation.

This research axis is prior for our research group, it allows to feed case studies dealing with Industry 4.0 to link research findings with IMS research projects namely: “BEST 4.0” and Industry 4.0 European Project “I4EU”.

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