With Lean Thinking and Industry 4.0 to Operational Excellence

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Summary

Companies across all industries implemented the principles of Lean Thinking in order to generate competitive advantage. Now, a plateau regarding the impact has been reached. Today, significant improvements can be made by using digital technology to achieve operational excellence. The available amount of data that is generated every day can be processed and analysed due to steadily increasing computational power. Additionally, the usage of technologies such as additive layer manufacturing, augmented reality or the cooperation of humans and robots has reached maturity. Mutually, Lean and Industry 4.0 solutions can help companies to reduce "wastes" according to Lean Thinking: e. g. unnecessary transportation, over-production, inventory levels, waiting times or also defects. First publications indicate that the resulting improvements due to Industry 4.0 are expected to cover a range of approximately 20% to 50+% waste reduction in the future. The recommended approach is to establish a solid Lean foundation first, and then to support the value adding processes by digital technology. It is important that in addition to Lean and Industry 4.0 also a strategy for a successful cultural change is required to move significantly closer to Operational Excellence.

The Lean Foundation

Lean Thinking has demonstrated to contribute to the generation of competitive advantage in the domains of supply chain and operations but also in product development, administration and services. Basic ideas of Lean Thinking are, for example, customer focus, cooperation, respect, as well as lifelong learning and continuous improvement. Hence, it can be implemented throughout the whole organisation to convert a company into a lean enterprise [Dennis 2010]. In simplified terms, it is about generating added value for customers while preventing all kinds of wasted efforts. Thus, Lean is a significant factor contributing to achieve Supply Chain and Operational Excellence [Liker/Trachilis 2014; Ivanov et al. 2017]. Lean is characterized by a set of key principles which are leading to the reduction of the so-called 7+x wastes [see for example Womack et al. 2007; Dennis 2010; Ivanov et al. 2017] as the following Figure 1 summarizes.

Enterprises put a lot of effort into the transformation towards a Lean organisation, but a certain plateau regarding the impact has been reached [Tsipoulanidis

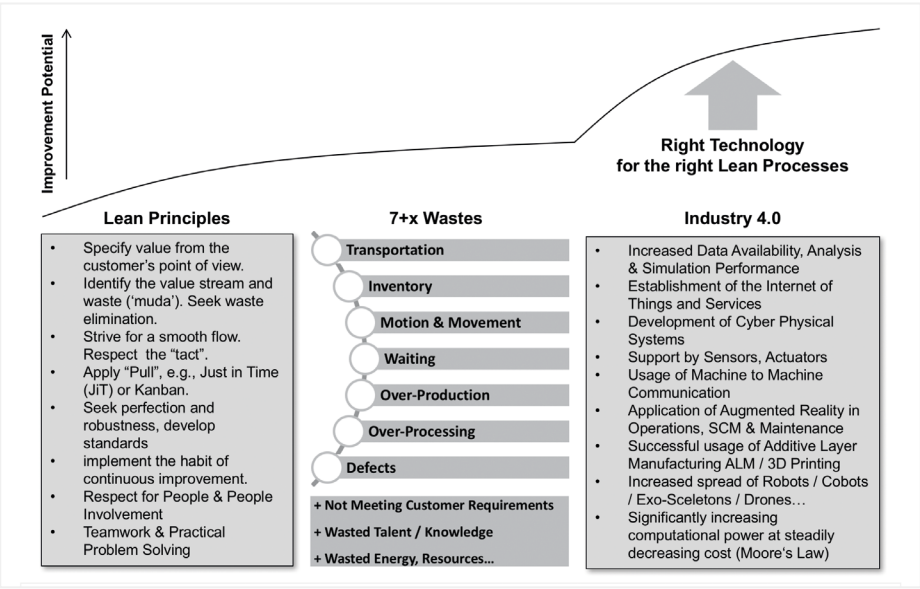

Figure 1:
From Lean to Leandustry 4.0 [Tsipoulanidis 2017]

2015]. Scheel et al. [2015] state that „traditional Lean has lost its teeth". One reason for that is a lack of Lean Leadership and Culture [Liker/Trachilis 2014]. Another reason is related to the insufficient usage of technology which helps to climb new levels of Lean [Tsipoulanidis 2017], and so "digital lean is giving rise to a new era in operations excellence [Scheel et al. 2015, p.1]."

Next Level of Lean in Times of Digital Transformation

The digital transformation enables firms to set up Smart Factories or adjustable production and logistics networks, also referred to as "Industry 4.0". "In essence, Industry 4.0 will involve the technical integration of Cyber Physical Systems into manufacturing and logistics, and the use of the Internet of Things and Services in industrial processes. This will have implications for value creation, business models, downstream services, and work organisation [BMBF 2013, p. 14]." As a result, value adding processes will improve on their own. That means, the fundamental idea of "continuous improvement" is no longer purely connected to the human being. The self-organised improvement of operational process, material movement, production flow and supply chain activities will lead to the so-called 'Smart Factory [see Bauerhansel et al. 2014]. It is clear, that the classical Lean principles, to avoid these non-value-adding activities, represent the basis for efficient value creation processes. A research study by Staufen AG [2016] shows that Lean can be considered as the foundation for Industry 4.0. Also, Lean will continuously further develop with the opportunities of Industry 4.0. Schneider [2017, p. 36] also states "Lean prior to Industry 4.0", and explains that in a first step processes and structures in the organisation will need to be optimized under consideration of Lean principles. In a second step, the appropriate Industry 4.0 technologies need to be assessed which will support the established Lean processes and structures.

According to a recent trend study [Logistik für Unternehmen 11/12-2016, p. 22] covering Germany, Austria and Switzerland (DACH), only 5% of the participating production and logistics companies fully exploited the huge potentials of the Internet of Things (IoT) for Supply Chains and Operations, in 2016. But due to the introduction of Industry 4.0, a whole new level of Lean can be reached, because now the information and big data is available, and the computational power to further process and analyse it [see Westerman et al. 2014; Brynjolfsson/McAffe 2015]. That enables firms to reduce wastes which couldn't be avoided before. That can be considered as the effect of "Leandustry 4.0" [Tsipoulanidis, 2015]. Porter and Heppelmann [2015] summarized that a whole new era of Lean will be seen. Data that is flowing to and from products will allow product use and activities across the value chain to be streamlined in countless new ways, and so waste will be cut or eliminated.

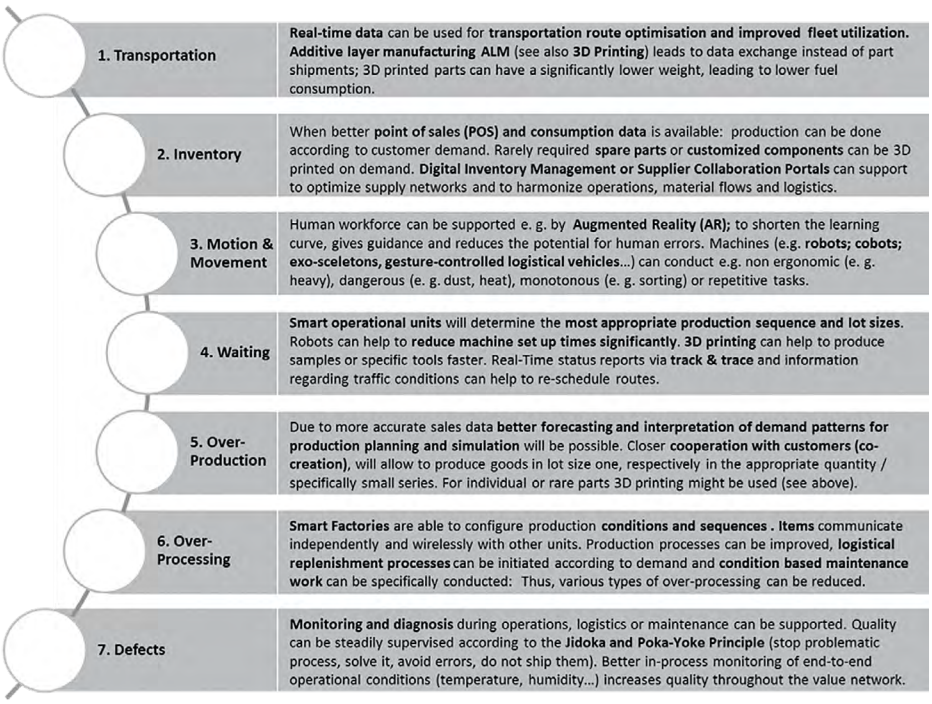

Figure 2: Examples of improvements due to Industry 4.0 in line with the 7 wastes of Lean Thinking [Tsipoulanidis 2017]

The key question is: what are the achievable improvements or in other words the expected potentials? This question will be pursued in the following section.

Identified Improvements Due to Industry 4.0 in Line with Lean Thinking

Industry 4.0 makes it possible to reduce the above mentioned classical Lean 7+x wastes in different ways. In general, it could be stated that the identified improvements lead to a resource efficient production according to the needs of customers, but also to improved logistics and transport. In more detail, it is expected that Lean and Industry 4.0 will help to reduce, for example, the following aspects shown in Figure 2. This illustration should also serve as "food for thought", indicating potentials that are relevant use cases for the individual reader of this article. The knowledge about the complementary synergy of classical Lean principles with digital technology is not yet widely used. According to the „Trends and Strategy in Logistics and Supply Chain Management" study by the BVL (Bundesvereinigung Logistik) approximately ¾ of the companies consider the opportunities related to the digital transformation as „high" or „very high", but more than 50% of the companies still prefer to wait until proven solutions are available [Logistik für Unternehmen 11/12-2016, p. 6]. As mentioned above, the reasonable combination of Lean and Industry 4.0 shows a very high potential. Identified quantitative potentials are discussed in the following section to substantiate it.

"Industry 4.0 will make it possible to reduce the classical Lean 7+x wastes in many different ways. Overall, significant improvements are expected to be achieved over the next ten years."

Quantified Potentials of Industry 4.0 in Line with Lean Thinking

As a result of analyses of academic theses and interviews, important first insights have been consolidated. Balayan [2015, p. 60] interviewed a group of experts who estimated, that the influence of Industry 4.0 will have a significant impact on the reduction of unnecessary inventory, waiting and defects. Hamadeh [2016] concluded that the expected waste reduction might be between 15% to 30% over all waste types, in the near future. Leichsenring [2016] presented a projection of future potential estimations over the next 5 to 10 years that indicate an expected reduction of the 7+x wastes between 50% to 60% from today's baseline. As these expert estimations are limited and not representative, published quantitative data from practice has been collected to further substantiate the expert views.

According to a survey by Alicke et al. [2016, p. 7], "the potential impact of Supply Chain 4.0 in the next two to three years is huge – up to 30% lower operational costs and a reduction of 75 % in lost sales while decreasing inventories by up to 75 % are expected." Another huge factor is the potential reduction of forecasting errors. Due to predictive analytics in demand planning, it is expected that forecasting errors can be reduced by 30 – 50%, as Alicke and his team found out. The consulting company 4Flow presented a case at the company AGCO, where logistics costs were reduced by 28% due to the implementation of their digital supply chain concept [4Flow 2016; Logistik für Unternehmen 11/12-2016, p. 8-9]. Overall, significant improvements are expected to be achieved over the next ten years. According to another study, "industrial-component manufacturers stand to achieve some of the biggest productivity improvements (20 to 30 percent), for example, and automotive companies can expect increases of 10 to 20 percent [BCG 2015]." Other companies refer to productivity improvements of approximately 10% due to the usage of RFID along the value chain. Furthermore, it was determined, that an increased transparency and flexibility leads to optimized usage of resources. In the farming industry, up to 15% increase in productivity can be achieved [Deutsche Telekom AG 2013]. Wildemann [2016] presents that productivity in the automotive sector has increased by 10 – 15%. Also inventory levels are expected to be reduced by 30% due to the combination of material and information flows.

What are the reasons for these significant improvements? One area besides big data analytics is the usage of e. g. robots, cobots, augmented reality or additive layer manufacturing in supply chains and operations [HWR IBCON projects 2016 and 2017]. Furthermore, these robots are getting more intelligent and thus they can become a real assistant for the classical workers and conduct 30 – 50% routine tasks. Another example is that due to the usage of robots for machine set up tasks, the waiting time can be reduced by 50% [Continental Automotive Spain 2016]. Asche [2017] presents the impressive example that the weight of a part can be reduced from 14,3 kg to 2,9 kg when it is 3D printed. Of course, these few presented quantitative potentials vary from industry to industry and they can only be considered as first rough indications. All sources identified significant improvements due to digital transformation, intensively contributing to a reduction of the presented 7+x wastes of classical Lean Thinking, which is symbolically illustrated in Figure 3. To summarize, there is a strong linkage between improved, i. e. reduced, transportation and reduced fuel

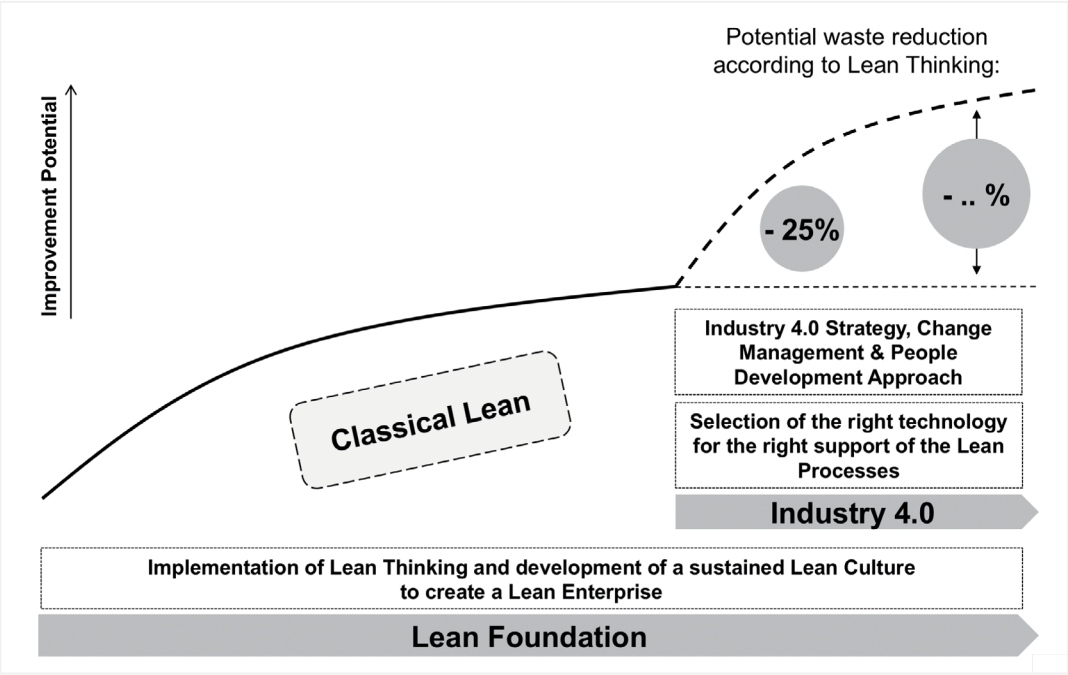

Figure 3: Connection of Lean Thinking and Industry 4.0 [Tsipoulanidis 2017]

consumption leading to lower emissions and pollution. Furthermore, a reduction of waiting time leads to higher capacity utilization. A reduction of over-produced items leads to lower inventory levels and so on. That means according to Lean Thinking, the different types of "waste" are mutually connected together and digital technology is expected to have a leverage effect on the reduction of the 7+x wastes.

Required Change Management Strategy

To improve value adding processes, new technologies are just one element on the pathway to operational excellence. "To achieve strong financial impact from improvements in analytics, manufacturers must also consider the human factor. As in previous efforts to optimize production, such as Lean manufacturing or ISO quality standards, change-management capabilities will be crucial. The new horizon in analytics will achieve its full impact only when manufacturers enhance skills across the entire organizations so that the new methods and solutions become a part of the day-to-day routine [Feldmann et al. 2017]." That means – also in line with the classical principles of Lean Thinking – a respective culture needs to be established in the companies that are going through the digital transformation. One needs to learn from mistakes of early Lean implementations. Possible reasons of failure need to be identified, and a strategy to convert them into success factors has to be developed. Zeh [2016] and Dalgic [2016] analysed crucial barriers (reasons for failure) as well as the success factors, to establish a "Leandustry 4.0 Culture". Examples of identified barriers and obstacles that hinder the development of a respective culture are shown in the following Figure 4. Bhasin [2015, p. 27] stated that approximately 80% of the success of a transformation depends on the human being, and the culture.

It confirms that the identified obstacles (Figure 4) need to be turned into factors for implementation success.

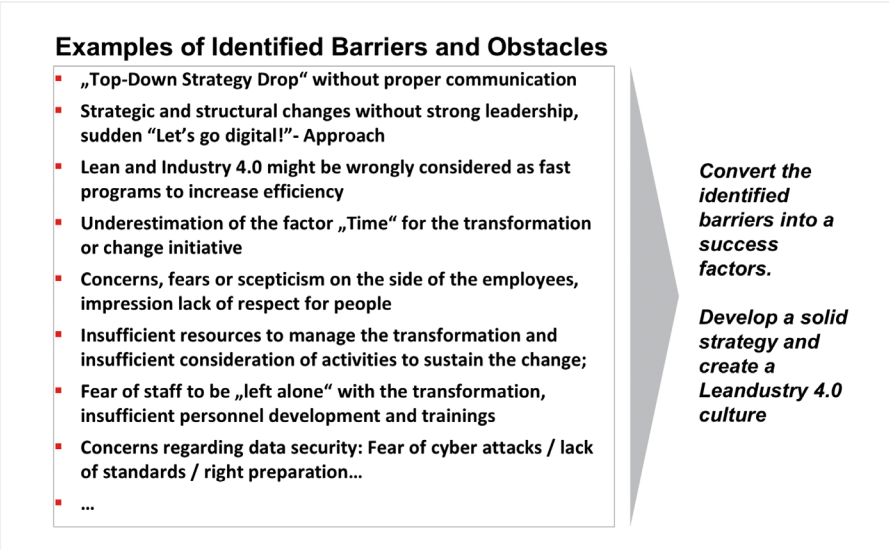

Figure 4: Convert barriers into an improvement strategy to create a Leandustry 4.0 culture [Tsipoulanidis 2017]

Kiehne and Tsipoulanidis [2016] also elaborated on the importance of the development of digital competencies in Supply Chain and Operations Management in the early stage of academic education, which is key in our very dynamic business environment.

Conclusion

The presented benefits of Industry 4.0 in connection with the achievement of the next level of Lean and the reduction of the 7+x wastes are impressive. In short, it means that due to digital technology the prerequisites are in place to produce customised products in small quantities. At the same time, the number of variants and throughput can be increased, capacities can be better utilized to a higher degree and in parallel inventory levels, transport efforts, and resulting emissions can be reduced. Once a Lean foundation has been established in the organisation, the effects of appropriate digital solutions and technologies to support Lean value adding processes will need to be assessed.

As the last section highlights, it is of equal importance to develop a Leandustry 4.0 culture. In order to benefit from the complementary benefits of Lean and Industry 4.0 described in this paper and to convert it finally into a framework for operational excellence, companies will need to put a very strong focus on a few more key aspects such as the development of a strategy for a structured Lean and Industry 4.0 implementation approach, solid change management with strong leadership and steady communication combined with the enhancement of the skills and competencies of their most important asset: their employees.

"First Lean and then Industry 4.0: it requires a structured implementation approach, solid change management with strong leadership, combined with the enhancement of the skills and the competencies of the employees."

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Zusammenfassung

Seit Jahrzehnten implementieren Unternehmen verschiedenster Industrien und Größen die Ansätze des Lean Thinking, um nachhaltige Wettbewerbsvorteile zu generieren, jedoch wurde mit den traditionellen Methoden ein gewisses Plateau erreicht.

Heutzutage können signifikante Verbesserungen in den Wertschöpfungsprozessen durch Nutzung der verfügbaren digitalen Technologien erreicht werden. Die täglich generierten Daten lassen sich nun analysieren und interpretieren, da die Leistungsfähigkeit der Rechner stetig wächst und parallel die Kosten fallen. Zusätzlich haben Technologien wie der 3D-Druck, Augmented Reality oder die Roboternutzung die erforderliche Reife erreicht, so dass damit ein neues Niveau in der Vermeidung von Verschwendungen gemäß der Lean Philosophie erreicht werden kann: z. B. die Vermeidung unnützer Transporte, Wartezeiten, Bestände oder Defekte. Erste Publikationen deuten an, dass Reduzierungen dieser Verschwendungen in Größenordnungen von 20% bis 50% und sogar mehr erzielt werden könnten.

Die empfohlene Herangehensweise dabei ist, zunächst ein Lean Fundament im Unternehmen auszubauen, um dann gezielt die digitalen Technologien bzw. Industrie 4.0 Szenarien im Einklang mit den schlanken Wertschöpfungsprozessen auszuprägen. Es ist ferner erforderlich, dies mit einer robusten Industrie 4.0 Strategie, einem soliden Change Management und einem gezielten Ansatz zur Mitarbeiterqualifikation zu verknüpfen, um dem Ziel der operativen Exzellenz ein großes Stück näher zu kommen.

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