The Relationship between Lean and Industry 4.0: Literature Review

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Abstract

Some companies adopt a new manufacturing revolution called industry 4.0 and a number of them are lean companies. Industry 4.0 helps companies be more flexible and could respond to the market change easier. Also, it increases product quality and profitability. A growing number of scientists investigated the influence of integration lean and industry 4.0 over the past years. Thus, this paper identifies major gaps for association linking lean and industry 4.0. To execute the research, 35 papers have been reviewed and a classification scheme for them was developed. In order to make the relationship between lean and industry 4.0 transparent, this paper provides a quantitative and qualitative analysis. The quantitative analysis shows in 2 figures also, the result of the qualitative analysis is presented in 3 separate sections titled as follows: 1. Lean is a basis for industry 4.0, 2. Interaction industry 4.0 and lean and, 3. Industry 4.0 completes lean.

Key words
Industry 4.0, Lean production, Lean manufacturing, Lean management, Integration lean and industry 4.0.

1. Introduction
Before 1908, the only methodology for producing cars was craft production (James P Womack, Jones, & Roos, 2007), in this method all parts of the cars were assembled by one person. As there wasn't a defined standard, the components were not interchangeable. Henry Ford introduced mass production in 1908 by model T, it was a revolutionized methodology and vital changes have been happened in the automobile industry, since then the production speed increased dramatically. Ford succeed to increase demand through reducing the cost per car from $800 to $200, so car became affordable to common family. Ford Company had the largest share of the market in the automotive industry for around 45 years via adopting mass production until Toyota Company emerged its Toyota production systems. Taiichi ohno and Eiji Toyoda traveled to ford company to learn mass production methodology. They determined mass production is unadoptable in Japan because Toyota couldn't afford the expensive mass production facilities like in the US and Toyota could not afford to maintain high inventory. In the meanwhile, Ohno and Toyoda found out mass production is full of waste, so they utilized Ford's ideas and focused on reducing waste and low-cost automation, finally, they introduced Toyota production systems. Toyota succeeded to increase profitability through removing wastes in the production process from the customer's order and supply chain to the final delivery of the product to the customer. Toyota production systems acted as a competitive advantage in Toyota cooperation and it could become the market leader in this gigantic industry. Toyota production systems called lean by John Krafcik in his article titled Triumph of the Lean Production System in 1988.

The first industrial revolution happened in the 18th century when water power and steam power were utilized in the industrial process, it is called mechanization. The second one is identified by using electricity in the production process, this facilitates mass production in order to respond to the accelerating population growth after the world

war II (Blanchet, Rinn, Von Thaden, & De Thieulloy, 2014). The third industrial revolution was automation through entrance programming and robotic arms in the mechanical process (Zhou, Liu, & Zhou).

Industry 4.0 (I4.0) is the fourth industrial revolution and was proposed for the first time at Hanover University in 2011 by the German government in cooperation with Universities and Companies. The summary of the characteristics of the industrial revolutions is illustrated in Figure 1. There are similar methods to I4.0 in other countries for example, Industrial internet in the United States and Internet+ in China. Industrial internet and industry 4.0 have a considerable overlap but there are some changes too (Boyes, Hallaq, Cunningham, & Watson, 2018). The main characteristics of I4.0 are connected machines, smart products and systems, and interrelated solutions (Tortorella & Fettermann, 2017). In implementing I4.0 some aspects like the computers and digital components integrate together for monitor and control physical devices (Ashton, 2009). I4.0 is a strategic plan and it aims to enhance productivity and efficiency through developing advanced production system (Frank, Dalenogare, & Ayala, 2019). Big changes happened in consequence of implementing I4.0 in the organizations, for instance, companies become more flexible in time and space.

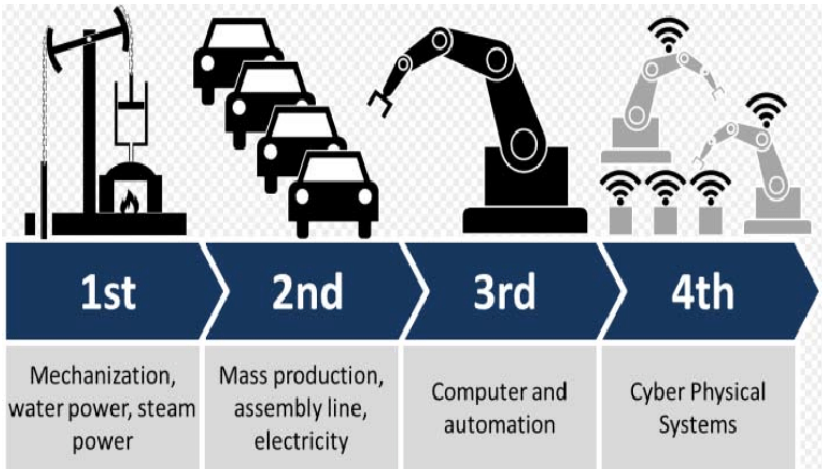

Figure 1. Summary of the characteristics of the industrial revolutions (Chute & French, 2019)

Also, workflow is expected to become more transparent, decentralized and less hierarchical (Sanders, Elangeswaran, & Wulfsberg, 2016). Additionally, digitalization is a risk and in some countries workers are the most defenseless group (Segal, 2018). The key objective of I4.0 is to drive manufacturing to be more effective, customer-oriented and faster. It is an enhancement in digitalization and automation manufacturing environment, moreover, it creates strong communication between products, machines and business partners through a digital value chain (Şenkayas & Gürsoy, 2018).

This paper carries out a literature review with a view to identifying the relationship between lean and I4.0 and the influence on each other. Several companies integrate lean and I4.0 to reach higher quality and reduce costs. This paper considers the influence of this integration in different industrial sections when both methods are implemented completely.

2. Literature review

2.1 Lean

Since introducing lean for the first time, scientists published a huge number of articles in this field and investigators agree on the positive impact of lean on production performance although, there was no unanimous definition of lean between them. Lean can be adopted in all sections of the company (Hines, Holweg, & Rich, 2004) and most companies prefer to start implementing lean from shop floor (Shah & Ward, 2007).

The main objective of lean is to make continuous improvement and reduce cost through eliminating wastes (non-value-added activity) and increasing process efficiency. Lean introduced several tools like 5S, Just in time, Jidoka, Heijunka, Kaizen, etc. Lean is a competitive advantage and is considered as one of the key methods in increasing

profitability (Garre, Bharadwaj, Shashank, Harish, & Dheeraj, 2017) and customer value. Lean concept is, do the most with least (Ozkeser, 2018), to achieve high performance with fewer resource.

Krijnen (2007) introduced seven original wastes of lean. They are inventory, waiting, defects, overproduction, motion, transportation, and over-processing. When Toyota production system was adopted in Europe, the workers' non-utilized talents and skills were introduced as the 8th waste of lean.

Figure 2. Seven types of wastes

The raw materials and work in process that maintained, identified as the inventory. Waiting occurs when a worker can't proceed to the next task in a process, it means doing nothing or acting slowly whilst waiting for the previous step in the manufacturing line.

Also, defects happen when products deviate from what is the customer's demand. Overproduction means producing more than what's actually needed which is the worst waste. Motion happens when there is an unnecessary moving during the manufacturing process. Transportation is to transport products in order to continue manufacturing process between different sections of the factory. Finally, over-processing is each action that does not add value to the customer.

Lean companies use five general principles to remove wastes, Shah and Ward (2007) introduced these principles as follows:
"defining the value from the customer perspective, mapping the value stream process to achieve the predefined value, creating the flow along the value chain, establishing pull system and pursuing perfection..."
Also, James P Womack and Jones (1997) described the summary of these principles as follows:
"Precisely specify value by specific product, identify the value stream for each product, make value flow without interruptions, let the customer pull value from the producer, and pursue perfection..."
Managers can utilize the benefits of lean by understanding lean principles completely and implementing them precisely.

Lean production contributes in improving operational performance in developed and developing countries (Shah & Ward, 2003). There are numbers of companies adopting lean production, most of them could improve their efficiency, whilst some companies failed in adopting lean successfully in consequence of misunderstanding of how lean principles work (Shah & Ward, 2007). Implementing successfully need prerequisites as Lewis (2000) mentioned context is vital in adopting lean successfully. Hence, alterations in internal and external scenarios are the most common cause in lean production failure (Rossini, Costa, Tortorella, & Portioli-Staudacher, 2019). Moreover, the characteristic of different regions and industries contribute in implementing lean (Marodin, Frank, Tortorella, &

Fetterman, 2019). Different industrial sections implement lean production (Martinez-Jurado & Moyano-Fuentes, 2014) (James P. Womack & Jones, 2015). It is a complex task and companies face a huge number of barriers during the process and the brilliant result couldn't be achieved in the first attempt (Martinez-Jurado & Moyano-Fuentes, 2014) (Scherrer-Rathje, Boyle, & Deflorin, 2009), in fact, lean production is not a one night process.

2.1 Industry 4.0

I4.0 introduces a system that makes intelligent decisions automatically based on analysis of data (Ahuett-Garza & Kurfess, 2018). It is different from current systems in which only a computer controls automated facility.
Hermann, Pentek, and Otto defined I4.0 as follows:
"Industrie 4.0 is a collective term for technologies and concepts of value chain organisation. Within the modular structured Smart Factories of Industrie 4.0, CPS monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. Over the IoT, CPS communicate and cooperate with each other and humans in real time. Via the IOS, both internal and cross-organizational services are offered and utilized by participants of the value chain…"

I4.0 contains four key components: Cyber physical systems (CPS), Internet of things (IoT), Internet of services (IoS) and smart factory (Hermann, Pentek, & Otto, 2016). CPS elevates machines to a higher level and gives them intelligence and automation also, it is integration computations with intelligent physical processes like computers. Physical processes and computations affect each other with the feedback loop. Machines can diagnose defects by sensors and report it to the operator on the smartwatch also, activate the process for solving the problem by actuators automatically. The smart factory is in the center of I4.0 and it helps organizations to handle complexity and unexpected interrupts. IoT and IoS attempt to create a smart environment through connecting products, machines, and workers in the factory (Sanders et al., 2016). A large amount of data is gathered and shared with other devices by IoT through cloud computing and the system utilizes the collected and stored data for analyzing the process (Arcidiacono & Pieroni, 2018).

Six design principles for I4.0 are introduced that support companies to increase automation, reduce manufacturing costs and increase profitability, these principles are: interoperability, real-time capability, virtualization, modularity, decentralization, and service orientation (Hermann et al., 2016). Scurati et al. (2018) believes that the key objectives of I4.0 are expanding digitalization in manufacturing environment and increasing automation in order to create close communication between products, manufacturing environment and business partners.

3. Methodology

It is essential to do full investigation of the resources to reach the research goals. This paper concentrates on articles dealing with lean and industry 4.0 in terms of the relationship and influence on each other when two methods are implemented completely. So, candidates used the Google Scholar search engine and ÉTS bibliothèque that were connected to databases like Science Direct, IEEE Xplore, Emerald, and Springer to find relevant literature. Candidates searched the following keywords to prepare the research in *titles.*

- 'Lean' and 'Industry 4.0'
- 'Lean organization' and 'Industry 4.0'
- 'Lean production' and 'Industry 4.0'
- 'Lean manufacturing' and 'Industry 4.0'
- 'Lean six sigma' and 'Industry 4.0'
- 'Lean automation' and 'Industry 4.0'
- 'Lean management' and 'Industry 4.0'

As I4.0 is still in its infancy, the result of this process was only 35 articles published between the years 2015 and 2019. Candidates have examined each article to ensure that the content is pertinent to the perspective of the goals of current research. Finally, 22 papers have been chosen that their contribution is a relationship between lean and I4.0 and their influence on each other when the two methods are implemented completely. In terms of quantitative analysis, the following items are selected: nationality of authors, kind of paper and year published. Also, the results for qualitative analysis are presented in 3 Tables based on different opinions about the relationship between lean and I4.0.

4. Results

The target of the article is to review the literatures related to integrating lean and I4.0. In consequence, 35 papers from different sections have been reviewed and finally, the candidates have chosen 22 papers for analysis. Quantitative analysis shows scientists paid attention to this context since 2015 (1 Article) and the most articles published in 2018 (9 Articles), it shows a dramatic increase in this context over the past years. The most dominant nationality of the scientists is Germany (40%), followed by Italy and Portugal (12%). Also, 80% of the articles are published by European scientists. The articles have been selected from different kinds of paper publishing centers, 64% conference articles, and 36% journal articles. The results of the quantitative analysis are illustrated in two charts in figure 3.

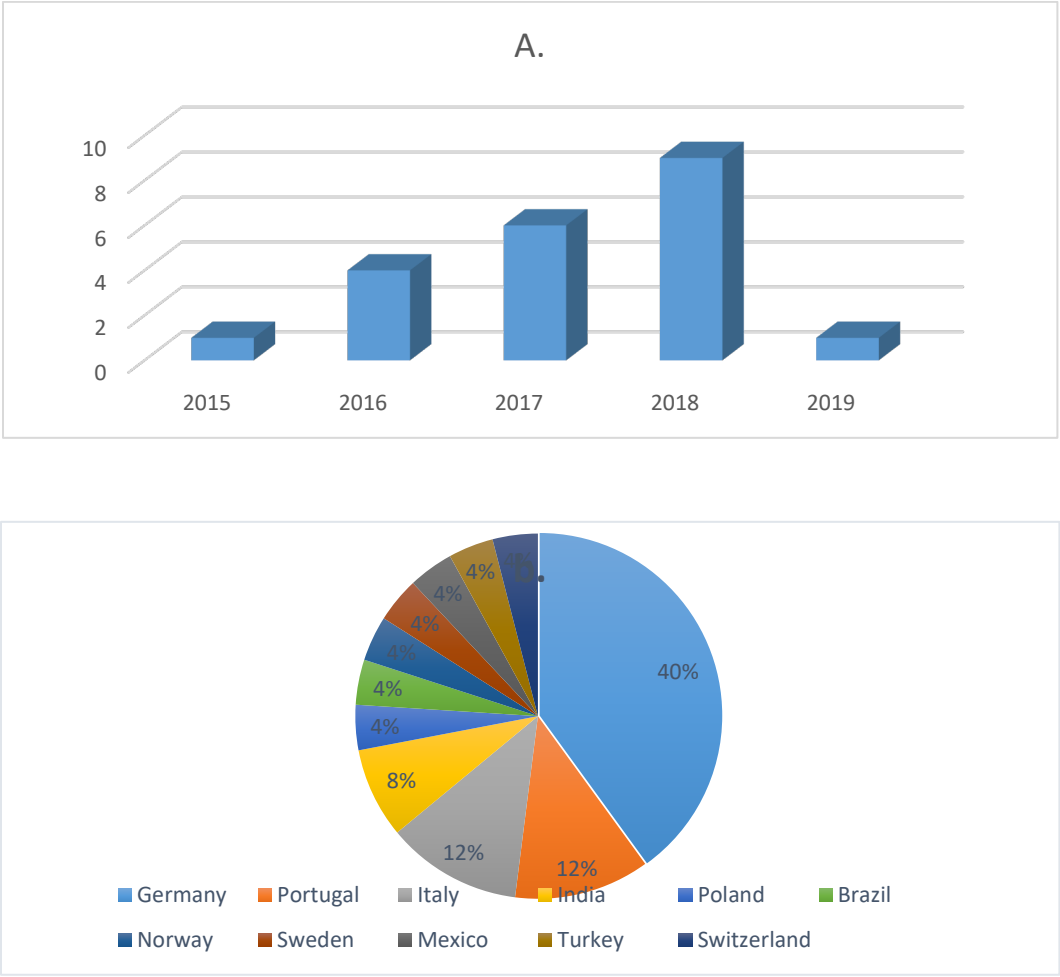

Figure 3. The number of articles A. by year, B. by country

The qualitative analysis illustrates that there are different ways that lean and I4.0 influence each other. The various opinions are classified into 3 separate sections:

1) Lean acts as a basis for industry 4.0.
2) Industry 4.0 and lean interact with each other.
3) Industry 4.0 completes lean and increases lean efficiency.

The results are provided in the following sections.

4.1 Lean is a basis for industry 4.0

As it is illustrated in Table 1, 4 articles stated, lean acts as a basis for I4.0. Tortorella and Fettermann (2017) mentioned that the combination of two methods elevates the profitability and the company's background is vital for

lean production, meanwhile the authors have confirmed that the companies with low experience (less than 2 years) in the lean production field have no extensive association between lean production and I4.0. Although surprisingly, the authors have founded companies poorly associate lean production, and I4.0 show a high level of performance; also, the size of the company is not vital in adopting them.

Tortorella and Fettermann (2017) and Rossini et al. (2019) concluded the chance for implementing I4.0 is higher in companies adopting lean production enormously. Leyh, Martin, and Schäffer (2017) classified 31 I4.0 models and stated, lean management and lean production are the basis for I4.0 although, it is not addressed in I4.0 models. Information and communication technology are the most important factor in the environment that the integration of lean production and I4.0 occurs. Furthermore, Rossini et al. (2019) emphasized the importance of lean production and continuous improvement in adopting new methodologies like I4.0 and Dombrowski and Richter (2018) confirmed the aforementioned statements; meanwhile, they mentioned lean acts as a basis and prerequisite for I4.0. The authors introduced lean production framework 4.0 (LPS 4.0) by the combination of LPS and I4.0.

4.2 Interaction industry 4.0 and lean

Sanders, Subramanian, Redlich, and Wulfsberg (2017) believed interaction between I4.0 and lean causes synergies and helps them to adopt precisely. The current investigation found 5 papers that confirm this issue. Mayr et al. (2018) explored whether lean management and I4.0 can support each other or not. In consequence of this article, the terms Just in time 4.0 (JIT 4.0), Just in sequence 4.0 (JIS 4.0) Heijunka 4.0, etc have been introduced. The authors believed these two methods can support each other on a conceptual level and I4.0 supports lean methods in a condensed way.

The influence of I4.0 and lean manufacturing on sustainability has been explored by Varela, Araújo, Ávila, Castro, and Putnik (2019) according to 252 valid answers to the survey applied in industrial companies located in Portugal and Spain. The article has had three main achievements:

- The authors emphasized, there is a correlation between I4.0 and environmental sustainability (High), social sustainability (Medium) and economic sustainability (Low).
- The correlation between I4.0 and lean manufacturing has been observed dramatically
- Len manufacturing has no influence on sustainability.

Satoglu, Ustundag, Cevikcan, and Durmusoglu (2018) believed I4.0 and lean manufacturing are not mutually exclusive and need to be integrated also, I4.0 can solve the problems that exist in adopting lean manufacturing. The relationship between I4.0 and lean manufacturing is vital for the quality and reliability of products. Additionally, there is a high level of synergies between them. Dombrowski, Richter, and Krenkel (2017) concluded high dependencies between cloud computing, avoidance of waste, zero defect, and big data. The data analysis has been showed that horizontal integration doesn't have a high impact on LPS principles. The summary of the results for this section are listed in Table 2.

4.3 Industry 4.0 completes lean

The number of articles in which the authors have believed I4.0 completes lean and solves the challenges related to implementation lean is 13. The overview of the results is indicated in Table 3. Mrugalska and Wyrwicka (2017) explored the influence of smart products and machines on continuous improvement. The authors believed they decrease the time between failure occurrence and failure notification via smartwatches (Smart operation) (Mrugalska & Wyrwicka, 2017) (Kolberg & Zühlke, 2015), meanwhile, actuators activate the process for solving the problem automatically. Also, Kolberg and Zühlke (2015) asserted smart products make Kaizen less labour-intensive and more precise because data is gathered per product individually for value stream mapping.

Wagner, Herrmann, and Thiede (2017) focused on the combination of CPS and JIT (Cyber-physical just in time) and they claimed it has a positive impact on transparency and minimizes working space. Furthermore, Sanders et al. (2016) mentioned, lean and I4.0 have a positive correlation, besides, implementation of I4.0 helps companies to overcome challenges in the way of lean. Moreover, Axelsson, Fröberg, and Eriksson (2018) believed I4.0 improves quality via reducing wastes and improving communication and coordination.

Butollo, Jürgens, and Krzywdzinski (2019) looked at the relationship between lean and I4.0 via different vision, in fact, the authors investigated the autonomy in the work process. Results showed that I4.0 provides solution for increasing demand for changing schedule and companies won't be employee-oriented also, the results clearly emphasized on the positive impact of these methods on greater task rotation and decreasing the bargaining power of the workers. Meanwhile, D'antonio and Chiabert (2018) asserted I4.0 reduces the number of employees on the shop floor because it increases the ability of the operators via physical and cognitive interaction with the machine.

One worth pursuing influence of I4.0 and lean is on the supply chain, Susana Duarte and V Cruz-Machado (2017) and Susana Duarte and Virgilio Cruz-Machado (2017) stated that I4.0 improves supply chain, makes it smart and more flexible through smart data that provides a high level of data sharing for green supply chain and lean. Totally, the authors claimed I4.0 improves the influence of lean method in supply chain.
Rüttimann and Stöckli (2016) have contrasting opinions, assumed I4.0 is on the top of the cake, makes lean faster, smoother and more accurate in manufacturing companies although, they believed lean transformation has better results in comparison with implementing I4.0 and I4.0 won't be a revolution. Jayaram (2016) focused on globalizing supply chain via creating heavy communication between companies. He claimed lean six sigma removes unnecessory process and the result of the implementing I4.0 would be faster and more efficient supply chain.

Beifert, Gerlitz, and Prause (2017) paid attention to the shortcomings in lean manufacturing in shipbuilding and the solutions that I4.0 presents. The authors have asserted lean principles are inadequate for shipbuilding because of the high market volatility and transaction costs and I4.0 provides the solutions. Powell, Romero, Gaiardelli, Cimini, and Cavalieri (2018) investigated how I4.0 supports key lean manufacturing constructs in an Italian company in the automotive sector. They have stated that I4.0 could coordinate supply chain and support Just-in-time (JIT) also, Heijunka becomes more realizable and it is optimized through big data and real-time remote visibility.

5. Discussion

The results of this article are 3 different points of view about the combination of two methods. Most of the reviewed articles have confirmed I4.0 completes lean, make lean stronger and more efficient. On the one hand, scientists acknowledge integration has positive impact on the value of the product, customer satisfaction, and competitiveness. On the other hand, they are unanimous about the way that two methods influence each other. There are several frameworks and models for integration but there are still issues that are considered as unsolved or inadequately addressed. In consequence, future researches are needed to reach a common understanding.

This literature review has two limitations: first, there is subjective bias in selection of articles and review of them. For the objectives of the paper only scientific articles have been chosen and the commercial publications have been ignored. Second, in some articles, the results have been described qualitatively. It is strict to extract the outcome of integration lean and I4.0 base of qualitative analysis.

Candidates have selected papers when lean and industry 4.0 are adopted completely, but some organizations can't implement two methods entirely because of the implementation barriers. Furthermore, in some cases, managers prefer to implement only some principles of lean and industry 4.0 due to the unsuitability of the principles in special industry. It is clear that results of amalgamation of two methodologies are different in this situation, it could be considered as future research. Also, the current paper has investigated pieces of literature in all types of industries and the results may be various in some special industries. This circumstance is suggested for future investigation too.

6. Conclusion

Lean could finish the dominance of mass production in the automotive section and its being spread to other industries quickly. Lean considers any activity which does not add value to the product as waste and remove them from manufacturing process to reduce the costs. I4.0 optimizes the computerization of the third industrial revolution and it makes manufacturing process smarter, more effective and productive. Most authors confirm that the integration of lean and I4.0 has positive impacts on companies though, there is no similar opinion about the way that the two approaches influence each other. In this paper the review of the literature about lean and I4.0 was presented to illustrate the whole vision of different possibilities in linking two methods.

Table 1. Lean is basis for industry 4.0.

Reference	Contribution	Factors	Results
(Tortorella & Fettermann, 2017)	-The influence of implementing I4.0 on lean production according to operational performance improvement and the size of the company.	-Time of implementing lean production -Frequency -Adjusted residual	-High level lean production companies have more chance in implementing I4.0 in emerging economies. -Combining lean production with I4.0 elevates the profit. -Company background is vital in adopting lean production.
(Leyh et al., 2017)	-The relationship between lean production and 31 I4.0 classified models.	-Communication between Man-Man, Machine-Man Machine-Machine	-Information and communication technology are vital factors in the integration of lean production and industry 4.0 environments. -Lean management and lean production principles are the basis for I4.0.
(Rossini et al., 2019)	-Investigation of the relationship between I4.0 and lean production in 108 lean European companies that start to adopt I4.0.	-Augment reality -Cloud computing -Integrated engineering system	-Adopting emergent methodologies are lower in companies in which lean production and continuous improvement are not established and are designed weakly. -I4.0 and lean production are correlated strongly.
(Dombrowski & Richter, 2018)	-Combining I4.0 and LPS in consequence, creates LPS 4.0.	-LPS 4.0 -Data management provision of information/data	-Lean build the biases for the adoption of I4.0. -I4.0 should be integrated with LPS to enhance LPS. -LPS is a prerequisite for I4.0.

Table 2. Interaction industry 4.0 and lean.

Reference	Contribution	Factors	Results
(Dombrowski et al., 2017)	-Different type of industry 4.0 elements have been organized to technologies, systems, and process-related characteristics.	-Cloud computing and -Big data -Horizontal and vertical Integration	-Higher dependencies between: 1. cloud computing and avoidance of waste and LPS principles. 2. Zero defect and big data.
(Mayr et al., 2018)	-How I4.0 can support lean methods.	-Just in sequence 4.0 -Heijunka 4.0, Kanban 4.0, VSM 4.0, and JIT 4.0	-LM and I4.0 support each other. -I4.0 tools can support the analyzed lean methods in a condensed way.
(Varela et al., 2019)	-The influence of I4.0 and lean manufacturing on sustainability have been measured qualitatively biased on 252 valid answer to the survey.	-Environmental, Social and Economic sustainability	-Correlation between I4.0 and environmental, social and economic sustainability. -There is no relation between lean manufacturing and sustainability.
(Satoglu et al., 2018)	-How I4.0 and automation innovative technology support implementation of LM.	-Additive manufacturing -Augmented reality -Simulation and virtualization -Overproduction and Inventory	-LM and I4.0 are not mutually exclusive and should be integrated. -The I4.0 tools can provide solution to difficulties related to lean manufacturing like mismanagement and weakly-organized manufacturing systems. -Implementing lean manufacturing and I4.0 results in saving data correctly.
(Sanders et al., 2017)	-Exploring the interaction between lean management and I4.0.	-TPM -Takt time -SMED -VSM standardization	-The most support to the lean tools has been received from real time, decentralized and interoperability. -Numerous synergies between lean management tools and I4.0 principles. -Lean management tools are the prerequisite for I4.0.

Table 3. Industry 4.0 completes lean.

Reference	Contribution	Factors	Results
(Mrugalska & Wyrwicka, 2017)	-Smart products and machines impact on Kaizen. -Augmented operator impact on Jidoka through recognizing the fault automatically.	-Kaizen -Kanban -Jidoka	-Pave the way of lean in terms of Kaizen. -Give better operational intelligence -Drop the time between failure notification and failure occurrence.
(Wagner et al., 2017)	-Impact CPS on JIT (Cyber physical just in time) material process.	-CPS -Big data analytic -Kanban card	-Increase transparency and stability of lean production. -Eliminate the shop floor. -Minimize the warehouse space.
(Sanders et al., 2016)	-The gap between realms of lean and I4.0. -Analysis of the barriers for lean implementation due to the lack of resources.	-Smart factory -Non-value added -Challenge to implement lean -Dimension of lean	-I4.0 makes factory lean beside being smart. -The positive correlation between lean and I4.0. -Companies could overcome challenges for lean implementation through adopting I4.0.
(Jayaram, 2016)	-Globalizing the supply chain through communication between components of an industry.	-global supply chain -Production monitoring -Industrial IoT	-Lean six sigma eliminates unnecessary process and defects. -I4.0 and IIoT make systematic management of the supply chain more efficient and faster.
(Axelsson et al., 2018)	-Outlined system of systems concept for improving productivity in road construction via lean and I4.0.	-Reference Architecture Model for Industry 4.0 (RAMI 4.0) -Hierarchical decomposition	-Improve the coordination of working machines. -Improve quality through reducing wastes and improve communication and coordination.
(Butollo et al., 2019)	-Analyzing the autonomy in the work process in organizations that apply lean and I4.0.	-Autonomy - Interdependencies -Task rotation -Employee-oriented	-Close linked value chain and industry structures are prerequisites for higher quality. -I4.0 and lean have a positive impact on greater task rotation. -New methods decrease the bargaining power of the workers.
(Susana Duarte & V Cruz-Machado, 2017)	-How I4.0 is combined with lean and green supply chain -The influence of I4.0 on lean and green supply chain.	-IoT -Smart data -Smart supplier -Smart logistics	-I4.0 makes the supply chain more flexible with more visibility. -I4.0 evolves lean and supply chain. -The supply chain has been improved by IoT. -I4.0 develops close cooperation with suppliers.
(Kolberg & Zühlke, 2015)	-Investigation influence of I4.0 principles in lean automation.	-Kaizen -Smart operator, product, machines, and planer	-I4.0 completes and supports lean. -I4.0 improves lean production. -Lean helps I4.0 to accelerate. -Smart products make Kaizen less labor-intensive.
(Rüttimann & Stöckli, 2016)	-How lean be considered in the context of I4.0 initiative.	-Smart factory -Big data and IoT -Virtual reality	-I4.0 makes lean more stable and accurate also makes it faster and smother. -I4.0 should integrate into lean but I4.0 won't be occurred as a revolution.
(D'antonio & Chiabert, 2018)	-The influence of I4.0 in non-utilized employee's talents that is caused by the separation between the management and the process operations in lean organizations.	-Operator 4.0 -Human CPS -Intelligent personal assistants -Social networks	-Reduces the number of employees in shop-floor. -Transfers shift of human job towards the non-routine task. -Increases the ability of the operator through physical and cognitive interaction with machines.

(Susana Duarte & Virgilio Cruz-Machado, 2017)	-A conceptual model that combines I4.0 in lean and green supply chain.	-Smart logistics -Smart products -Smart supplier -Smart operator -Smart manufacturing	-I4.0 improves lean. -I4.0 makes all concept of lean and supply chain smart. -Lean supports the installation of I4.0. -The green supply chain supports the implementation of the I4.0.
(Beifert et al., 2017)	-The way that I4.0 can deal with shortcoming sin lean manufacturing of the shipbuilding sector.	-Lean modeling and lean optimization tools -Potential cybercrime	-I4.0 solves the problems related to inadequate adoption lean and accelerate engagement of shipbuilding supplier. -I4.0 is a competitive advantage for SMEs and develops them in a smart approach.
(Powell et al., 2018)	-Investigation the potential of I4.0 to support key lean manufacturing constructs in an Italian company related to the automotive section.	-Just-in-time -Heijunka -Real time -Big data	- presents an approach to coordinate supply chain and supports just-in-time. -real time remote visibility optimizes elimination of wastes from overproduction.

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