

INTEGRATING LEAN MANUFACTURING AND SUSTAINABILITY: A PROPOSED MODEL

Zahra Abd Mohammed, Mustansiriyah University/College of Administration and Economics

ABSTRACT

The challenges that have emerged in the recent years, such as the lack of the resources, affect the survival and continuity of the business, but the resources can be managed effectively through applying the leanness as a philosophy that leads the company, its projects and activities to a state of continuous improvement. Nowadays the economic, environmental, social, and technology challenges are getting more and more complex, which forces the industrial companies' management to work on adopting the lean manufacturing where it focuses on the activities that add a value by eliminating the waste in all company operations, and this consequently leads to reduce the use of the materials, the inventory, the machinery, the space and production time as well as improving the efficiency in order to obtain products that have a high quality and for achieving this step, the elements, the practices and tools of the lean manufacturing must be applied, which in turn lead to achieve the economic, environmental, social, and technology sustainability.

The research aimed to develop an integrated conceptual model for the integration of the lean manufacturing and sustainability, because the previous studies did not provide an integrated model linking between the Lean Manufacturing and Sustainability and where it will achieve this by identifying the elements, the practices, and tools of the lean manufacturing that have an important and significant role in achieving the economic, environmental, social, and technology sustainability.

Keywords: Lean Manufacturing, Waste, Sustainability, Lean Manufacturing Elements, Lean Manufacturing Practices, Lean Manufacturing Tools

INTRODUCTION

The lean manufacturing is defined as a methodology for eliminating waste in all aspects of the company's operations through the continuous improvement, whereas the sustainability is defined as the meeting of the needs of the present time without compromising on the ability of the future generations so that they can meet their needs. Thus, the sustainability has three dimensions which are the economic, social and environmental ones. Therefore, the industrial companies must be viable, and pay special attention to the environment, so that they can realize a good work environment for the individuals. Moreover, from an economic point of view, the companies must grow without compromising on the ability of the future generations in order to meet their needs socially. Thus, they must create a sound work environment in addition to preserve the safety of workers, and therefore, the companies must environmentally take care of the environment.

Through the literary reviews of the lean manufacturing subject and sustainability, it is clearly appeared that there isn't any study that has presented an integrated model, but we find that every researcher has presented a different view and while (Resta et al., 2016) indicated that there is a relationship between the sustainability and lean manufacturing elements, we see that (Iranmanesh et al., 2019) explained that there is the relationship between the Lean manufacturing practices and sustainable performance, but (Järvenpää & Lanz, 2020) referred to the reduction of the losses, safety improvement, workers' respect, and production achievement as steps that lead to the sustainability

After reviewing many of the literature, the research is aimed to develop a proposed conceptual model for the integration of the lean manufacturing and sustainability, where it depends on the elements, the practices, and tools that will have a role in achieving the sustainability with its economic, environmental, social, and technological dimensions.

The research consists of five sections, the first section deals with an introduction, the second section concerns with the research methodology, while the third section discusses the literary review of the lean manufacturing and sustainability and the link between them. The fourth section focuses on presenting a proposed integrated conceptual model for the integration between the lean manufacturing and sustainability. For the model, it is presenting the elements, the practices, and tools of the lean manufacturing, as well as dealing with the dimensions of the economic, environmental, social, and technology sustainability. Finally, the fifth section presents the research discussion.

RESEARCH METHODOLOGY

Research Problem

Several researchers have presented researches and studies related to the lean manufacturing and sustainability integration. However, every researcher focused on one aspect of the lean manufacturing but he neglected the rest of the other aspects, so there is still a need to develop an integrated conceptual model that includes the lean manufacturing elements, practices, and tools that have a significant impact on achieving the sustainability with its economic, environmental, social, and technology dimensions.

Research Objective

The main objective of the research to develop a proposed conceptual model for the integration of the lean manufacturing and sustainability, where the model depends on the elements, practices, and tools that will have an important, essential and influential role in achieving sustainability with its economic, environmental, social, and technology dimensions. And to achieve this, the research present scientific texts related to the elements, practices, and tools that explain how Lean Manufacturing is integrated with sustainability.

Previous Studies

- 1) The study of (Kováčová, 2013) showed that there is an integration between the lean manufacturing and sustainability by relying on the lean manufacturing tools (value stream map, work teams, 5Ss, analysis tools, 5Whys) in order to achieve the sustainability.
- 2) The study of (Resta et al., 2016) mentioned to the relationship between the elements of the lean Manufacturing (JIT, TQM, TPM, HRM) and sustainability (environmental, social, and economic).
- 3) The study of (Iranmanesh et al., 2019) showed that there is a relationship between the lean manufacturing practices (process and equipment, manufacturing planning and control, human resource practices, product design, supplier's relationships, and customer's relationships) and sustainable performance.
- 4) The study of (Järvenpää & Lanz, 2020) mentioned that the waste reduction can achieve the economic and environmental sustainability, whereas the improving safety improvement can achieve the social sustainability. Also, the workers' respect can achieve the social and economic sustainability, and finally the production levels can achieve the economic and social sustainability too.

LITERARY REVIEW

Lean Manufacturing

The lean manufacturing term has been coined by (Krafcik, 1988; Shah & Ward 2007:787) but it was used first in 1990 by (Womack, Jones & Daniel Roos) in their book "The

Machine That Changed the World" (Stevenson, 2018). In 1992, the companies in the United States as well as in the world began to apply the lean manufacturing, but the year 1997 witnessed the verification of success for the factors in the used manufacturing methods, and in 2006 the lean manufacturing was applied in many companies around the world (Johnson, 2008).

Leaning means a manufacturing philosophy that emphasizes the minimizing of the amount of all resources including the time that is used in the various activities of the companies, or it is a philosophy that works to identify and eliminate the non-value activities that are added to the design, the production, the supply chain management, and dealing with customers (Bozarth & Handfield, 2016), or the leaning means working more with fewer resources, and this refers to the use of less space, less transportation, less stock, less human effort, and the use of fewer resources (Maia et al., 2013). Moreover, the leaning is considered as a philosophy of how to operate the operations, a means of planning and controlling on the operations, and a set of tools that improve the performance of the operations (Slack et al., 2013). Thus, the Lean processes can be considered as a highly coordinated system that uses the least amount of resources (materials, inventory, space, and investment) and produces the highest possibility of goods and services that have the highest quality (Stevenson, 2018:609). The lean management methods are summarized in three concepts: eliminating of waste/losses, maintaining of the quality of products/services, and accelerating of production to implement the concept of leaning (Florescu & Barabbas, 2018).

The wastes are defined as any activity that consumes the resources and does not add any value for many areas of the company (Abu Shaaban, 2012). There are several types of wastes /losses that are mentioned by (Slack et al., 2018; Krajewski et al., 2016; Cachon & Terwiesch, 2017; Swink et al., 2014).

Overproduction: This type of waste occurs by requesting more than the required quantity at the end of use or requesting it before it is needed. Accordingly, this leads to an increase in the storage, as well as there are products that are damaged as a result of the storage, and in both cases it leads to an increase in the costs and required space for the storage.

Inappropriate Processing: It includes the unnecessary steps in designing and manufacturing the product, which don't add any value or it is resulted from an improper maintenance, which requires re-designing the product and processes or canceling the redundant processes, and all of which causes an increase in the costs as well as the required time to achieve the process of the manufacturing.

- 1) **Transportation:** It includes the unnecessary steps for the raw materials and storage in the operation, or the transportation between the factories or work centers, or the increased handling, or due to the poor internal arrangement, all of which does not lead to add any value to the product, but in the opposite it causes increased costs and delay in the manufacturing time.
- 2) **Waiting:** It includes the delays or stoppages that occur when the raw materials, the workers, or information are not ready, or when there is a breakdown in the machinery which causes the waiting until repairing the breakdown.
- 3) **Inventory:** Any logistical activity that leads to more inventory (raw materials, in-process storage, and finished products), and which accumulates more than what is required, it will lead to an increase in the costs. Also, the increase in the inventory requires an additional space, and thus, this requires additional costs.
- 4) **Movement:** The unnecessary movement of the workers for instance (searching for things), this will greatly impede the workflow, as well as create an inappropriate work environment that leads to an increased stress for the workers and an increase in the wasted time and thus, it will reduce the efficiency.
- 5) **Errors and Defects:** This refers to any activity that causes unnecessary rework and modification, as well as the production of that defective materials that need to a repair or rework, and which finally leads to a waste of money or energies.
- 6) **Space:** It means the use more space than optimal.
- 7) **Underutilization of Employees:** The weakness or lack of an appropriate training, the lack of an appropriate work environment, the absence of an organizational culture, the high turnover of workers and others factors all lead to a lack of utilizing the physical abilities, knowledge, experiences, creative skills, and mentality of workers.

- 8) **Correction:** This type of waste occurs as a result of the lack of corrective actions for the errors that occur. The failure to use the corrective measures leads to an increase in the total costs, impede the proper flow of work, and increase the required time for the production process.

The elimination of all types of the waste is considered as the first step towards the lean manufacturing, which in turn is the decisive factor in achieving the sustainability with its economic, environmental, social, and technology dimensions and the figure (1) shows the types of wastes.

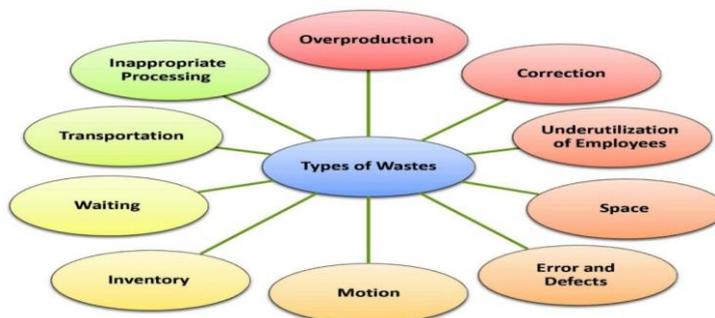


FIGURE 1
TYPES OF WASTE

The lean manufacturing is defined as an integrated management system that focuses on eliminating the waste and losses through continuous improvement of the process (Russell & Taylor, 2011), or it can be as an integrated set of designed activities to complete or achieve the production through the use of the least amount of the raw materials, in-process production, and finished goods (Jacobs et al., 2018).

In modern world, many of the world's leading companies are implementing Lean Manufacturing effectively such as Toyota, Boeing, GE, Ford, Alcoa, Airbus, Xerox, Scania and others (Khamidullina & Puryaev, 2016).

Sustainability

Each of (Rosen & Shawy, 2012; Maia et al., 2013; Spiegel et al., 2015; Järvenpää & Lanz, 2020) mentioned that the sustainability means meeting the needs of the present without compromising on the ability of the future generations so that they can meet their own needs). Moreover, the sustainability simply means, in its essence, the ability to endure or survive, since it is addressed the economic, social and environmental aspects simultaneously and comprehensively during the development process. Therefore, the sustainability has been applied in many fields, such as the engineering, the design, and manufacturing (Rosen & Shawy, 2012). Also the companies are beginning to feel under more pressure by stakeholders than ever before, as the conditions of the long-term organizational survival have changed, and from the perspective of the institutions, and their procedures to increase the competitiveness, the most efficient production has become a necessary and mandatory need to participate in environmental protection, community sustainability, and improvement of the economic performance, consequently the aspects of the environmental and social performance were included in their procedures in addition to the financial feature (Tăucean et al., 2019) and thus the sustainability is divided into three basic dimensions: economic, environmental, and social ones. In recent years, the technology dimension has been added (Rosen & Shawy, 2012; Spiegel et al., 2015).

Seven types of waste can be eliminated through the sustainability, (Järvenpää & Lanz, 2020) which are

- 1) The excessive use of the water.

- 2) The excessive use of the energy.
- 3) The excessive use of the resources.
- 4) The pollution.
- 5) The waste.
- 6) The effects of the global warming.
- 7) The poor health and safety.

Relationship between the Lean Manufacturing and Sustainability

The industrialization is playing a crucial role in the modern economic and social society and its activities have become a burden on the environment (Spiegel et al., 2015). Therefore, the lean manufacturing contributed to the trend towards the sustainability. After the year (2010) the number of researches that combine the lean manufacturing and sustainability have increased, and through their several similar goals and supported each other, in addition to the use of the lean manufacturing practices as a catalyst for developing the sustainability (Järvenpää & Lanz, 2020). Here, the firms became to realize the goals of sourcing more than simply eliminating the activities that don't add any value, but rather expanding the leaning goals to identify the ability in order to reduce the resource requirements and the ability to obtain the resources at lower cost (Fliedner, 2008). The lean manufacturing in the production system focuses on reducing or eliminating the operational wastes/ losses through the continuous improvement and the process changes to reduce the activities that don't add any value to the product, while the sustainability aims to eliminate the wastes/losses that affect the environment. The lean manufacturing has a positive effect in eliminating all activities that do not add any value such as the overproduction, the over-processing, the transportation, the waiting, the inventory, etc., the lean manufacturing will also have a positive impact on the energy management, the emissions management, the water management, and chemicals management (Iranmanesh et al., 2019). In the lean manufacturing environment, the sustainability refers to the systems that are productive for long periods of time with the growth in size and increasing complexity, through the practices that reduce the resource consumption or eliminate the environmental impacts (Fliedner, 2008). There is a relationship and interaction between the leaning and sustainability that contribute to increase the competitiveness and production efficiency, as leaning represents a comprehensive vision of the sustainability as well as simplifies the operations in terms of the waste, the cost, the quality, and time (Tăucean et al., 2019).

The sustainability is considered as a lean aspect but it extends to a much broader goal. A company that is familiar with the leanness can easily realize the sustainability (Kováčová, 2013). The leanness and sustainability are two sides of the same coin. Both seek to maximize the resource and economic efficiency. The leaning and sustainability lead to higher levels of performance. Moreover, the leaning and sustainability work on eliminating the wastes because wastes are costly and have a negative impact on the environment. Thus, the elimination of the waste is the common ground for the leanness and sustainability (Heizer et al., 2017). The relationship between the lean manufacturing and sustainability calls for a deeper understanding in order to accommodate trade-offs across economic, social, and environmental aspects (Francis & Thomas, 2019). Table No. (1) Shows the interdependence of the lean manufacturing and sustainability.

Table 1	
LEAN AND SUSTAINABILITY ARE CONNECTED	
Sustainability	Lean
Invest in long term- consider people, community, financials, environment	Long term philosophy- create value for people, community/ including environment/, economy

Ensure the ecosystem is in balance, if necessary, intervene in system	Create the right process to produce the right result
Invest in people- consider stockholders including your staff and partners/e.r. suppliers/	Add value by developing people and partners
Be transparent and consider the whole system vs. treating symptoms	Continuously making problems visible a solving root causes drivers organizational learning
Creating waste harms something else in the system	Minimize or eliminate waste of any kind

Source: (Kováčová, 2013:196)

Developing a Conceptual Model for Integrating the Lean Manufacturing and Sustainability

The lean and sustainability can contribute in increasing the competitiveness, the development ability, and increasing the efficiency of the resource use (material, financial, human, technology, and information). The research suggests developing an integrated conceptual model for the integration of lean manufacturing and sustainability, because most of the studies that dealt with the relationship between the lean manufacturing and sustainability were limited to one aspect of the lean manufacturing to achieve the sustainability. The figure (2) shows a proposed conceptual model and the following is an explanation for the paragraphs of the proposed conceptual model.

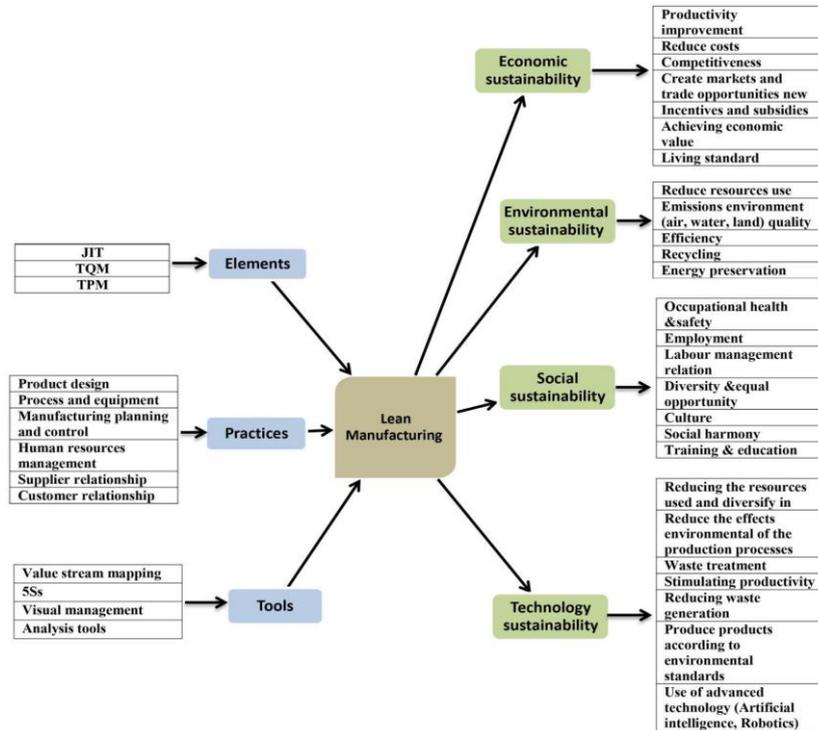


FIGURE 2
A PROPOSED CONCEPTUAL MODEL FOR THE INTEGRATION OF THE LEAN MANUFACTURING AND SUSTAINABILITY

Lean Manufacturing

The lean manufacturing is considered as a comprehensive concept for a group of elements, practices, and tools that aim to eliminate all wastes/losses (activities that don't add any value and consume the material, financial, human, and technology resources) from all aspects of the company, including the reduction of the used resources, the increase of the provided value for the customer, as well as the improvement of the environment and work in addition to encourage the teamwork, improve the competitiveness, and increase the profitability.

The researcher focuses on the texts of the elements, practices, and tools of the lean manufacturing that are related to achieve the sustainability in its four dimensions: economic, environmental, social, and technology ones in order to highlight its active role in creating integration between the lean manufacturing and sustainability.

Lean Manufacturing Elements

- 1) Just In Time: JIT is a comprehensive philosophy based on the concept of eliminating the waste (which includes the materials and equipment, the inventory and time, the energy and quality, the space and the human activity and waiting, the transportation, the movement, and internal arrangement) because it is considered as waste of anything that does not add any value. JIT is also considered as a philosophy that dominates all administrative aspects of the company such as the manufacturing, the personnel management, and suppliers' management. Moreover, JIT is also considered as a philosophy that is able to achieve products of high-quality and in high-volume at a low cost and at the same time it meets the needs of the customers accurately (Reid & Sanders, 2013:248). JIT is based on the Kanban system which is used to control the timing and movement of parts through a sequential process. Kanban is a simple and visual "parts withdrawal system" that involves cards and containers to pull parts from one work center to another in time, when all containers are filled, the production is stopped, and no more parts are produced until the next job (receipt) (Schroeder & Goldstein 2018:121), whereas the main purpose of Kanban is to reduce the stock (Heizer et al., 2017: 647), and since IT is a philosophy based on getting rid of all kinds of waste, accordingly the elimination of the waste will lead to economic, environmental, social, and technology sustainability.
- 2) Total quality management: TQM is an integrated management philosophy and set of practices that emphasize the continuous improvement and meeting customer's requirements, the reduction of the rework and long-term thinking, the increase of the employee engagement and teamwork, the process redesign and benchmarking, the competition and solving team-based problem, the continuous measurement of the results, and strengthening the relations with the suppliers (Shah & Ward, 2007: 788). As well as information and analysis, employee management, product and service design, Customer relationship management (Yeng et al., 2018:2). The lean manufacturing emphasizes the application of the quality at the source, (Russell & Taylor, 2011: 735.737-738), which includes:-
JIDOKA: For quality is everyone's responsibility in the company, employees are given the authority to stop the production line if there is a quality problem.

Pok-Yoke: Using the error-detection methods to design fail-safe systems in order to minimize the human error.

Andons: A system that provides the machines and their operators a signal about the quality problems as a result of happening an unusual state.

The concept of the continuous improvement is rooted in the quality, which means that the company must carry out the continuous and effective work. The continuous improvement includes the reduction of the batch sizes, the defective numbers, and installation costs, as well as improving the supplier relationships, and employee skills, the customer relationships, and management performance and others (Reid & Sanders, 2013). Therefore, the management must build a culture of continuous improvement and instill it in employees, because the continuous improvement is an integral part of the job of every worker (Haizer et al., 2017) and because TQM works to eliminate the unnecessary processes that increase the manufacturing costs and reduce the wastes/losses, especially eliminating the product defects, thus, TQM contributes to achieve the sustainability.

- 3) **Total productive maintenance:** When the lean manufacturing maintains a little inventory during the manufacturing process, any interruption in the machinery and equipment can cause major disruptions in the production (Stevenson, 2015), because they cannot operate continuously without maintenance and some care (Russell & Taylor, 2011). The Total Productive Maintenance (TPM) identifies and prevents all potential causes of failure to prevent the unplanned downtime. The typical TPM programs emphasize on the organization, and disciplined adherence to the operating procedures, the careful equipment design and maintenance, the manufacturing equipment, and a focus on preventing the problems rather than fixing them (Swink et al., 2014). Therefore, the replacement of the parts during regularly scheduled maintenance periods is easier and faster than dealing with the machine failures during manufacturing. Moreover, his maintenance is done according to a schedule, as well as making the workers responsible for maintaining their equipment by doing the routine maintenance (Krajewski et al., 2016).

Lean Manufacturing Practices

- 1) **Product Design:** In the lean manufacturing, a cross-functional design team design the product and during designing the product, especail consideration should be given to the standardization of parts and components, the manufacturability and assembly, in addition to reducing the total number of parts, and introducing the customer's requirements in order to simplify the process of designing, manufacturing, and assembling the product. The designers also focus at designing the product on the logistic services by reducing the size and weight of the product in order to reduce the packaging and shipping costs (Swink et al., 2014). The environmental issues are also taken into consideration when designing the product, in order to reduce the harmful environmental effects in all stages of the product's life, as well as reducing the use of the energy and harmful materials (Jacobs & Chase, 2018), and as a result of this step, more efficient products can be achieved in the environmental, economic, social, and technological dimensions.
- 2) **Process and Equipment:** The processes and equipment are represented the capabilities and practices of the improvement like the use of cellular manufacturing and reduction of setup times, the reduction of production cycle time and use of fault-resistant equipment, the availability and reliability of machinery and creation of an orderly system and uniform flow. The excessive production and incorrect processing lead to an excessive use of the machinery and equipment and waste of the energy, the water consumption and generation of the hazardous substances and emissions, an increase in the transportation and workers' increased movement and other wastes or losses (Iranmanesh et al., 2019).
- 3) The managers work to make the improvements by making the zero-emissions manufacturing, which requires capabilities to prevent the pollution such as the substitution and reuse of the waste. The lean manufacturing requires the ability of the flexible materials, and manufacturing equipment that can accommodate the variations in material flows, and thus, all these steps can all help to enhance the sustainability (Rosen & Shawy, 2012:158). The practices of the process and equipment achieve the environmental and economic sustainability by reducing the use of the materials, the energy and water, and also minimizing the generation of the waste. Consequently, this will be reflected in achieving the social sustainability by reducing the company's environmental impacts, which leads to the improvements in the work environment.
- 4) **Manufacturing Planning and Control:** The planning and control practices in the lean manufacturing are linked to the scheduling strategies in order to coordinate the production and market demand. This goal can be achieved through Pull-flow control, visual control, overlapped production, small lot sizing, synchronized scheduling, mixed model scheduling, under-capacity scheduling, and levelled production. The planning and control contribute in making the scheduling effective by reducing the work in the process, reducing the level of the manpower use, reducing the use of the raw materials, reducing the inventory, reducing the inventory during the operation, optimizing the use of the resources, and finally meeting the customer's demands. Moreover, the use of the withdrawal methods such as Kanban and small batch size can reduce the storage, and thus, reducing the wastes/ losses from the overproduction (Iranmanesh et al., 2019). Also, the planning and control practices reduce the wastes/ losses and defective materials during the process and improve the work conditions, and accordingly this is reflected in achieving the economic, social, environmental, and technology sustainability.
- 5) **Human Resource Management:** The lean manufacturing requires a comprehensive organizational reform and participation by all, this means that all parts of the company must work together, i.e. hand in hand (Reid & Sanders, 2013). The lean manufacturing at the work relies on the team approach, and therefore, it places a high value on the teamwork. Thus, when the representatives from different functional areas, suppliers and customers work together in a team environment, the problems are best solved, whereas, the responsibility to improve the product quality and its flow lies with the frontline workers who are more familiar with the processes that need to be improved. Hence, the workers are given the authority to stop the work when something is going wrong (Swink et al., 2014). So, just as, the lean manufacturing depends on an organizational culture and performance evaluation to create the long-term results, the sustainability depends on a new organizational culture by the workers (Florescu & Barabbas, 2018:1).

- 6) **Supplier Relationships:** In the lean manufacturing system, the relationship with the company's suppliers has changed radically, as suppliers are treated in the same way as the internal work centers that are part of the manufacturing team (Schroeder & Goldstein, 2018). The lean manufacturing requires the company to establish good cooperative relationships with the suppliers, and then, the company selects the suppliers that are close to it and expects them to supply the frequent shipments, in small batches, in short lead times, and with a high quality (Stevenson, 2018). The company seeks, through its cooperation and relationship with the suppliers, to reduce the wastage and waste, and to reduce the costs too, and at the same time to eliminate the unnecessary activities such as the receipt and check the received materials, eliminate the risks of transporting materials at long distances and stock damage by motivating the suppliers to choose locations close to the company in order to supply them with the materials in small frequent batches, disposal from the stock in the process at the production lines because the processor delivers small batches directly to the departments that are using these materials, and besides the selection of the most efficient processors to ensure the quality and reliability (Heizer et al., 2012). Moreover, the acceptance of allowing for the suppliers to participate in the product development provides opportunities to design new products and processes that are more efficient, in addition to take in consideration the environmental issues. Building reciprocal relationships between the companies and their suppliers opens new paths for the dissemination of the innovative methods to reduce the waste, enhances the productivity, and prevents the pollution, as companies help their suppliers to adopt new methods related to the environmental issues (Florida, 1996). Therefore, the company considers its suppliers as partners in the company (Krajewski et al., 2016).
- 7) **Customer's Relations:** The determination, development, and sustainability successful relationships with the customers over time require the use of the information and processes, the technology, and personnel to increase the customer retention (Bradshaw & Brash, 2001). The companies seek to establish relationships with their customers to ensure the reliable and fast deliveries and to achieve this, they must make orders more predictable and more stable, as well as improve the professionalism and efficiency of the workers who are directly involved with the customers (Abdul Wahab et al., 2013). Also, good relations with the customers lead to spread the conscious manufacturing practices environmentally and socially and produce only what customers demand (Florida, 1996).

Lean Manufacturing Tools

- 1) **Value Stream Map:** VSM is defined as a type of a flowchart tool used to develop the lean processes in order to give a visualization of the product flows through various process steps. The VSM describes the information that are used to control the flow through the process, as well as the information that are generated by the process (Jacobs et al., 2018:355). The sustainable value stream map has been used, where it is considered as an advanced and comprehensive way to understand the sequence of activities and information flows of all the required elements for the sustainability with the incorporation of the environmental, economic, and social considerations into manufacturing processes, (Jamil et al., 2020). The sustainable value stream map also represents an analysis tool that is capable of measuring the dimensions of the economic, environmental and social sustainability, showing the time and energy, the efficiency, and health as well as the safety (Hartini et al., 2018). VSM is widely used in leaning to see the whole picture and locate to which the improvement efforts are focused, and it easily extends to the sustainability, especially to the environmental aspect (Kováčová, 2013).
- 2) **5Ss:** It is a methodology for organizing, cleaning, developing and maintaining a productive work environment, also it is the cornerstone of reducing the waste and eliminating the unnecessary tasks, the activities and materials. It enables the workers to see everything differently and it prioritizes the tasks too. (Krajewski et al., 2016) mentioned that it consists of the following:-
- Sort: Separating the needed items from the unnecessary items.
 - Simplify: Organizing the work area so that it can be easy to find what is needed.
 - Shine: Cleaning and washing the work area in order to be bright.
 - Standardize: Establishing the schedules and methods for performing the processes of cleaning and sorting.
 - Sustain: Creating the discipline to execute the first four practices.

But (Haizer et al., 2017) added

- Safety: Building good safety practices into the previous five activities.
- Support: Reducing the unplanned vacation time and associated costs, as well as integrating the daily tasks with preventative maintenance.

There are many advantages for the 5Ss tool, such as productivity increase, employee morale improvement, and risk accidents reduction (Stevenson, 2018).

Visual Management: the visual management is a tool that enables the workers to be well informed of the manufacturing procedures and important information to their business performance. The visual management includes many means such as (charts, process metrics, procedures, written reports, instructions, and manufacturing information documents) which should be used in a way of a visual presentation that helps the work team to understand the complexities, the correct sequence for the work and the correct way of performing every part of the work as well as the internal and external relations (Abu Shaaban, 2012).

There are nine functions have been identified for the visual management: discipline, transparency, continuous improvement, training in the work location, work facilitation, management by facts, creating participation, simplification, and standardization.

Thus, the visual management eliminates wastes/ losses, promotes the continuous improvement, facilitates the employee independence, and allows the rapid response, which leads to the information sharing, the detection of defects and preservation of gains (Yik and Chin, 2019:3). The the work site organization and the visual management application help to improve the environmental performance level of the production line, whereas the attention to the occupational health and safety leads to a reduction in the level of injuries and work problems.

Analysis Tools: The traditional analytical tools, such as the Pareto chart, Ishikawa chart, and "5why's" can be used in analyzing the problem cause in order to determine he reason of the problems and why did they happen. (For example, the hazardous substances and emissions of toxic substances can be analyzed as if they were process defects) (Kováčová, 2013).

Sustainability Dimensions

The sustainability is considered one of the most important principles that came simultaneously with the increasing danger of the consumption of the input resources and negative effects of industrial activities on the environment, including the pollution and global warming, as well as the increase of the economic challenges as a result of the high costs of the energy and raw materials. The sustainability did not stop at this point, but rather focused on paying attention to the work environment in order to ensure the safety and health of workers, and sought to develop a new technology that would reduce the environmental impact.

- 1) **Economic Sustainability:** The economic sustainability is linked to the resource management strategies and in a way that leads to the financial benefits results for a long time (Florescu & Barabas, 2018). The lean manufacturing leads to the financial returns by attracting new customers, competitive differentiation, and reduces the costs through reducing the wastes/losses. Moreover, the lean manufacturing contributes in reducing the pollution, either by providing an information on the importance and value of the pollution reduction or by reducing the cost of implementing the environmental improvement (Iranmanesh et al., 2019). It is also possible to achieve a wide range of operational advantages at applying the lean manufacturing philosophy and practices, such as the production costs reduction, the quality improvement, the speed, and flexibility (Resta et al., 2016).
- 2) **Environmental Sustainability:** One of the changes in the corporate environment during the past years is the increasing demand for the social responsibility as a result of the resource depletion, the global warming and other environmental issues, and as a result, the environmental management has become an issue of a great importance (Flidner, 2008). The environmental sustainability seeks to reduce the negative effects of the business on the environment and conserve the resources (Järvenpää & Lanz, 2020: 6). Therefore, the industrial companies apply the lean manufacturing as a catalyst for improving the environmental practices, since the green environment represents a good general spread of Leaning. the lean practices and sustainability are described as a synergistic link between the environmental management and operations (Resta et al., 2016).
- 3) **Social Sustainability:** The social dimension is defined as the worker's right to work in a clean and sound environment through which he exercises his assigned activities (Yilmaza & Bakis, 2015). Thus, The use of the lean manufacturing to improve the financial and environmental results is not enough, so the managers need to pay a special attention to how to manage social performance effectively, and be aware of the

effects of lean practices on the social performance. Therefore, the lean practices reduce the stress and increase the independence,(Iranmanesh et al., 2019).Also the lean manufacturing has a positive impact on the health and safety in the work environment as a result of designing work stations in accordance with the specific standards, which improves the working conditions (Resta et al., 2016).

- 4) **Sustainability Technology:** The technology is an organized knowledge with which can improve the reduction of the environmental impact. Thus, Most of the developments related to environmental strategy result from the advancement of technology (Rosen & Shawy, 2012:158).Moreover, it is more preferable to use the technology that does not cause the emissions, the gases, and harmful substances, as well as has the ability to control, reduce, reuse or recycle the solid waste. Consequently, a clean and appropriate waste treatment technology must be used according to the economic, environmental, and social context (Santiago & Dias, 2014).

DISCUSSION

There is an agreement that if an activity does not add any value, it should be reduced or eliminated, because the activities that do not add any value, they will consume the resources. Nowadays, the industrial companies are under pressure from the stakeholders (governmental organizations, NGOs, customers, and society) to operate in a way that considers the sustainability.

From this point of view, the researcher reviewed many researches and studies related to the lean manufacturing and sustainability, and it was found that there isn't any research or study provided an integrated model for the integration of lean manufacturing and sustainability. The reason is that most researches and studies have focused on one aspect of the lean manufacturing, as well as they also dealt with the sustainability with its three dimensions: economic, environmental, and social only. Therefore, the present research aims to develop an integrated conceptual model for the integration of the lean manufacturing and sustainability. The idea of the research focused on the adoption of the lean manufacturing with all its areas (elements, practices, and tools) as an organizational basis for a work to achieve the sustainability with its economic, environmental, social, and technology dimensions. The model indicates that the application of the elements, practices, and tools of the lean manufacturing that work to eliminate all kinds of wastes/losses represented in the overproduction, an inappropriate processing, the transportation, the waiting, the inventory, the movement, the quality defects and other losses. The elimination of these wastes/losses will lead to reduce the resource consumption, reduce the raw material consumption, the energy management, the water management, the waste reduction, as well as reducing the global warming, in addition to provide products in accordance with the environmental and other standards, and thus, it is achieving the economic, environmental, social, and technology sustainability.

In the near future, many industrial companies that apply the lean manufacturing will be able to achieve the sustainability, because the Lean manufacturing is considered as an appropriate approach to achieve a new comprehensive vision of the sustainability for the companies seeking to achieve superiority in a world which witnesses a rapid development and change. The sustainability will also be of great and increasing importance in the product design and manufacturing process methods through an influential role in determining the main priorities for developing the product design, and for manufacturing the processes and technologies that will be adapted to the environmental, economic, social, and technology sustainability in all the industrial companies' types. Other dimensions of the sustainability will be added or expanded, which will be necessary and have an influential role in achieving the sustainability, such as the cognitive, cultural, political, and psychological dimension.

REFERENCES

- Abdul, A.N., Mukhtara, M., & Sulaiman, R. (2013). *Procedia Technology*, 11, 1292-1298.
- AbuShaaban, M.S. (2012). Wastes elimination as the first step for lean manufacturing : An empirical study for gaza strip manufacturing firms: *A thesis for degree of master business administration, Faculty of Commerce, the Islamic University of Gaza.*

- Andersson, S. (2007). *Implement Lean Production in small companies*, Thesis MSc in International Project Management, Chalmers University of Technology, Göteborg, Sweden.
- Cecil, B.C., & Robert, B. (2016). *Introduction to operations and supply chain management*, (4th edition), Pearson Education Limited, Boston.
- Bradshaw, D., & Brash, C. (2001). Managing customer relationships in the e-business world: How to personalize computer relationships for increased profitability. *International Journal of Retail & Distribution Management*, 29(12), 520-530.
- Gérard, C., & Christian, T. (2017). *Operations management*, (1st edition). Published by McGraw-Hill Education, U.S.A.
- Fliedner, G. (2008). *Sustainability: A new lean principle*. In: *Proceedings of the 39th annual meeting of the decision sciences institute, Baltimore, Maryland, November*, 3321-3326.
- Florescu, A., & Barabaş, B. (2018). Integrating the lean concept in sustainable manufacturing development. *IOP Conf. Series: Materials Science and Engineering*, 1-7.
- Florida, R. (1996). Lean and Green: The move to environmentally conscious manufacturing. *California Management Review*, 39, 1, 80-105.
- Francis, A., & Thomas, A. (2019). Integrating lean construction and sustainability via a system dynamics framework. In: *Proc. 27th Annual Conference of the International Group for Lean Construction (IGLC)*, At: Dublin, Ireland, 1187-1196.
- Hartini, S., Ciptomulyono, U., Anityasari, M., Sriyanto., & Pudjotomo, D. (2018). Sustainable-value stream mapping to evaluate sustainability performance: Case study in an Indonesian furniture company, MATEC Web of Conferences, 154, 1-7.
- Heizer, J., Render, B., & Munson, C. (2017). *Operations management sustainability and supply chain management*, (12th edition). Pearson education, Inc. U.S.A.
- Iranmanesh, M., Zailani, S., Hyun, S.S., Ali, M.H., & Kim, K. (2019). Impact of lean manufacturing practices on firms sustainable performance: Lean culture as a moderator. *Sustainability*, 11(4), 1-20.
- Jacobs, F.R., & Chase, R.B. (2018). *Operations and supply chain management*, (5th edition). McGraw- Hill Education, New York, U.S.A.
- Jamil, N., Gholami, H., Saman, M.Z.M., Streimikiene, D., Sharif, S., & Zakuan, N. (2020), DMAIC-based approach to sustainable value stream mapping: Towards a sustainable manufacturing system. *Economic Research*, 33(1), 331-360.
- Järvenpää, E., & Lanz, M. (2020). Lean manufacturing and sustainable development. *Responsible Consumption and Production*, 1-10.
- Khamidullina, A.M., & Puryaev, A.S. (2016). Study of lean production technology application at domestic and foreign enterprises, *Academy of Strategic Management Journal* 15(1), 61-66.
- Krajewski, L.J., Ritzman, L.P., & Malhotra, M.K. (2013). *Operations management: Processes and supply chains*, (10th edition), (Global edition), Pearson, Boston, U.S.A.
- Kováčová, I.L. (2013). The integration of lean management and sustainability. *Transfer innovation*, 26, 195-199.
- Maia, L.C., Alves, A.C., & Leão, C.P. (2013). Sustainable work environment with lean production in textile and clothing industry, *International Journal of Industrial Engineering and Management*, 4(3), 183-190.
- Reid, R.D., & Sanders, N.R. (2013). *Operations management: An integrated approach*, (5th edition). John Wiley and Sons, Inc., U.S.A.
- Resta, B., Dotti, S., Gaiardelli, P., & Boffelli, A. (2016). Lean manufacturing and sustainability: An integrated view. IFIP International Conference on Advances in Production Management Systems (APMS), September, Iguassu Falls, Brazil, 659-666.
- Rosen, M.A., & Kishawy, H.A. (2012). Sustainable manufacturing and design: Concepts, Practices and Needs, *Sustainability*, 4, 154-174.
- Russell, R., & Taylor, B.W. (2011). *Operations management: Creating value along the supply chain*, (7th edition). John Wiley and Sons, Inc., U.S.A.
- Santiago, L.S., & Dias, S.M.F. (2012). Matrix of sustainability indicators for the urban solid waste management , *Eng. Sanit. Ambient Journal*, 17(2), 203-212.
- Schroeder, R.G., & Goldstein S.M. (2018). *Operations management in the supply chain: Decisions and cases*, (7th edition). McGraw-Hill Education, 2 Penn Plaza, New York, U.S.A
- Shah, R., & Ward, P.T. (2007). Defining and developing measures of lean production. *Journal of Operations Management*, 25, 785-805.
- Singh, B., & Sharma, S.K. (2009). Value stream mapping as a versatile tool for lean implementation: An Indian case study of a manufacturing firm, *Measuring Business Excellence*, 13(3), 58-68.
- Slack, N., & Jones, A.B. (2018). *Operations and process management: Principles and Practice for Strategic Impact*, (5th edition). Pearson education limited, England.
- Slack, N., Jones, A.B., & Johnston, R. (2013). *Operation management*, (7th edition). Pearson Education Limited, England, U.K.
- Spiegel, D.V., Linke, B.S., Stauder, J., & Buchholz, S. (2015). Sustainability strategies of manufacturing companies on corporate, business and operational level. *International Journal of Strategic Engineering Asset Management*, 2(3), 1-20.

- Stevenson, W.J. (2018). *Operations management, (13th edition)*. McGraw-Hill Education, 2 Penn Plaza, New York, U.S.A.
- Stevenson, W.J. (2015). *Operations management, (12th edition)*. McGraw-Hill Education, 2 Penn Plaza, New York, U.S.A.
- Swink, M., Melnyk, S.A., Cooper, M.B., & Hartley, J.L. (2014). *Management operations across the supply chain, (2nd edition)*. McGraw- Hill Companies, Inc., New York, U.S.A
- Tăucean, I.M., Tămășilă, M., Ivascu, L., Miclea, S., & Negrut, M. (2019). Integrating sustainability and lean: SLIM method and enterprise game proposed. *Sustainability*, 1-28.
- Yeng, S.K., Jusoh, M.S., & Ishak, N.A. (2018). The impact of Total Quality Management (TQM) on competitive advantage: A conceptual mixed method study in the Malaysia Luxury Hotel Industries, *Academy of Strategic Management Journal*, 17(2), 1-10.
- Yik, L.K., & Chin, J.F. (2019). Application of 5S and visual management to improve shipment preparation of finished goods. *IOP Conference Series: Materials Science and Engineering*, 530, 1-14.
- Yilmaz, M., & Bakis, A. (2015). Sustainability in construction sector. *Procedia - Social and Behavioral Sciences Journal*, 195, 2253-2262.