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APPLYING LEAN PRODUCTION TOOLS TO REDUCE WASTE MANAGEMENT IN FOOD SECTOR

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ABSTRACT

APPLYING LEAN PRODUCTION TOOLS TO REDUCE WASTE MANAGEMENT IN FOOD SECTOR

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In today's world, the concept of lean has become a very important idea, widely used by many firms and industries. Lean ensures that waste is eliminated in a process, fewer resources are used, and thus high value-added activities and products are delivered to clients. Lean's most important focus is the concept of value. Therefore, the reduction and elimination of waste have become an important issue, as waste does not add any value to clients and the products. Lean shows itself more in the production sector. Lean production enables activities that do not add value and the elimination of waste in a production process, where lean production tools play an important role. Therefore, the aim of the thesis is to apply lean production tools in order to reduce and eliminate the seven lean wastes of lean production by selecting a food firm in the production sector. A focus group was formed with ten experts from a firm that produces poultry products and a questionnaire was prepared. Waste Relationship Matrix (WRM) and Best-Worst Method (BWM) were used. WRM was used to reveal the effect, affection, so relationship of waste on other wastes. With WRM, the ranking of waste that emerged in the firm was obtained. With BWM, the optimum weight ranking and consistency ratio of lean production tools were obtained in the firm. As a result, lean means of production corresponding to each lean waste were obtained and a relationship was established between lean waste and lean production tools.

Key Words: lean manufacturing, lean tools, lean waste, Waste Relationship Matrix, Best-Worst Method

ÖZ

GIDA SEKTÖRÜNDE ATIK YÖNETIMINI AZALTMAK IÇIN YALIN ÜRETIM ARAÇLARININ UYGULANMASI

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Günümüz dünyasında, yalın kavramı birçok firma ve sektör tarafından yaygın bir biçimde kullanılan, çok önemli bir düşünce haline gelmiştir. Yalın, bir süreçte atıkların elimine edilmesini, daha az kaynak kullanılmasını ve böylece, müşterilere, yüksek katma değerli eylemlerin ve ürünlerin sunulmasını sağlamaktadır. Yalının en önemli odak noktası, değer kavramıdır. Dolayısıyla, atıkların da, müşterilere ve ürünlere hiçbir değer katmaması nedeniyle, atıkların azaltılması ve ortadan kaldırılması önemli bir konu haline gelmiştir. Yalın, üretim sektöründe kendini daha fazla göstermektedir. Yalın üretim, bir üretim sürecinde, değer katmayan eylemleri ve atıkların elimine edilmesini sağlamaktadır ve burada yalın üretim araçları önemli bir rol oynamaktadır. Bu nedenle, tezin amacı, üretim sektöründe bir gıda firması seçilerek, yalın üretimin yedi yalın atığının azaltılması ve ortadan kaldırılması için yalın üretim araçlarının uygulanmasıdır. Kümes hayvanı ürünleri üreten bir gıda firmasından on uzmanın katıldığı bir odak grup oluşturuldu ve bir anket hazırlandı. Atık İlişki Matrisi (WRM) ve Best-Worst Metot (BWM) kullanıldı. Bir atığın, diğer atıklar üzerindeki etkisini, etkilenmesini yani ilişkisini ortaya çıkarmak için Atık İlişki Matrisi kullanıldı. Atık İlişki Matrisi ile, firmada ortaya çıkan atıkların sıralaması elde edildi. BWM ile, firmada, yalın üretim araçlarının optimum ağırlıklarının sıralaması ve tutarlılık oranı elde edildi. Sonuç olarak, her bir yalın atığa karşılık gelen yalın üretim araçları elde edildi ve yalın atıklar ve yalın üretim araçları arasında bir ilişki kuruldu.

Anahtar Kelimeler: yalın üretim, yalın araçlar, yalın atık , Atık İlişki Matrisi, Best-Worst Metot

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I would like to express my enduring love to my parents, who are always supportive, loving and caring to me in every possible way in my life.

Elif Kıran

İzmir, 2021

TEXT OF OATH

I declare and honestly confirm that my study, titled "APPLYING LEAN PRODUCTION TOOLS TO REDUCE WASTE MANAGEMENT IN FOOD SECTOR" and presented as a Master's Thesis, has been written without applying to any assistance inconsistent with scientific ethics and traditions. I declare, to the best of my knowledge and belief, that all content and ideas drawn directly or indirectly from external sources are indicated in the text and listed in the list of references.

Elif Kıran

May 26, 2021

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ABBREVIATIONS

ABBREVIATIONS:

TPS Toyota Production System

JIT Just in Time

VSM Value Stream Mapping

TPM Total Productivity Maintenance

SMED Single Minute Exchange of Dies

DMAIC Define, Measure, Analyze, Improve and Control

JIPM Japan Institute of Plant Maintenance

TQM Total Quality Management

3R Reuse, Recovery and Reduction

VA Value-Adding

NNVA Necessary but Non-Value Adding

NA Non-Value Adding

MRP Material Requirement Planning

VE Value Engineering

VA Value Analysis

WIP Work in Progress

CPI Continuous Process Improvement

COPQ Costs of Poor Quality

MCDM Multi-Criteria Decision-Making

BWM Best Worst Method

DM Decision Maker

GDP Gross Domestic Product

CHAPTER 1
LEAN PRODUCTION

1.1. Framework of Lean Production

A production sector is an important tool for the extension of economics. With the constantly changing global perimeter, competitive and staying of life challenges arise. Sectors attach great importance to lean production (Dutta and Banerjee, 2014). Lean production and its tools are extensively used in the production industry (Dal Forno and Forcellini, 2012) and it is spreading quickly whole up the world. The use of lean production occurs because producers want to remove or reduce waste (Durakovic et al., 2018). Lean production is known to be the most significant part of anything the system (Sundar et al., 2014). Today, it is an important approach for achieving perfection in lean production, processes, and services. Therefore, this lean production is widely used in production sectors in different parts of the world to increase fruitfulness and performance in processes (Prasad et al., 2018). In addition to the fact that lean production is used by every firm in the world, it also attracts great interest in the academic environment (Jasti and Kodali, 2015). Traditionally, the area of practice of the lean concept is production firms (Rossini and Staudacher, 2016) and it is implemented in a lot of sectors, not the auto sector, only because of the Toyota Production System (TPS) (Durakovic et al., 2018).

Lean Production is derived from Toyota's notion of Just in Time (JIT) production system used with a lot of production sectors (Saleh et al., 2016). With lean production, operation changing, and constant healing ways, it enables to decrease of non-value-adding (NVA) activities and to remove the waste generated in the production and in firms (Womack et al., 1990; Womack et al., 1991; Narasimhan et al., 2006; Antony et al., 2012; Jassim, 2018). Lean production is an effort to eliminate the waste of an operation (Womack and Jones, 2003). These wastes would arise from a lot of things like unnecessary steps, job instability, and quality problems (Oko, 2016). The layout utilized in lean production is that the production cell is parallel. There must not warehouse and this must a single piece of the stream in each cell. This flow is the foundation of lean production (Sultanov and Özçakar, 2010; Dutta and Banerjee, 2014). Lean production emerges from the necessity to raise the product stream rate by scrapping actions that do not form value. Thus, lean production is a process focused concept because it reduces redundant operations and actions in a firm and eliminates waste (Arnheiter and Maleyeff, 2005). Lean production is an operation that ensures fluidity and elasticity in one stream, continually healing quality, and removes waste (Saudi et al., 2019). This is the production used today, as it aims to eliminate NVA activities in firms and also determines seven kinds of lean waste, referred to as Muda (Ohno, 1988) and therefore, the purpose of lean production is to decrease the seven lean wastes and also another waste kind named- underutilization of people or employees (Sultanov and Özçakar, 2010; Arunagiri and Gnanavelbabu, 2016). Lean production is a work tactics focalized to decreasing waste like overproduction, inventory, transport, waiting, overprocessing, defects, and motion (Ohno, 1988). For example, lean production reduce waste of these kinds: These are correcting and maintenance operations when a device becomes distorted, to produce over than as it should be, unnecessary endeavor to transportation any type of goods, transportation of wastes, and holding surpluses such as finished products and raw materials (Dutta and Banerjee, 2014). It also reduces waste such as lean production, versatile employees, standardization of products and operations, removal of buffer stock, decrease in lot dimension, and working time (Ramaswamy et al., 2002). Lean production is easy, ergonomic, elastic, environmentalist, intensive, cheap price, right harmony, and use lesser power (Durkee, 2008).

In developed countries, firms working in lean have gained big advantages from lean directions. Lean production provides healing and development of quality, advancement, and low cost (Savaş and Kılıç, 2013; Oko, 2016). The main opinion of lean production is to increase client value while reducing waste (Wahab et al., 2013). Lean production focus on increasing competition thanks to value formation for clients (Johansson and Winroth, 2009). Lean production is also noted as a system connected to the supply chain in order to provide loud-capacity and elastic production with finished products using the least raw materials and to production satisfy wants (Lewis, 2000; Liker, 2004; Antony et al., 2012). In a production status; lean production would promote Information Techonology production plan, request and procurement plan and accountancy and client service (Ghaffari et al., 2014; Rai et al., 2015).

Lean production manufactures whatever the client needs, in the quantity she or he needs, at the time she or he needs, with the less source. Lean endeavors usually begin with production because it releases sources for constant healing in another field and forms a pull system to firms (Ashish, 2009). Lean production is made by true clients, not by market request predictions. This indicates that a request ‘pulls’ a product thanks to production and estimates that the administration will push into the production area. To do this, the lean concept prefers to optimize the focus of administration along with the value flow, vertically, to the client, rather than horizontally optimizing departments, assets, and technologies (Carvalho et al., 2017). Lean production offers its products to clients whenever and wherever they want due to constant healing and therefore a situation is where clients ‘pull’ request, and lean production is in motion (Heizer et al., 2007). Lean production occurs in a business administration that responds to the requests of the client with the least time, the most economical cost, and the best quality (Negrão et al., 2017). Lean production is an orderly system utilized to remove waste when concentrating on client wants. This system is named the production system from the 21st century. The important features of lean production are price, quality, security and delivery. Lean thinking concept provides low price, need a lesser human power, rise product improvement, reach more excellent quality, and create big gains (Thurston and Ulmer, 2016). The basic idea of lean production is to remove worthless actions from a value chain and benefit the client (Florida, 1996).

Lean production consolidates the top properties of mass production and craft production: These are the skill to decrease cost by the monad, offers a broad variety of products and improve quality if there is a tough job (Womack et al., 1990). Lean production is a Japanese system that opposes mass production, which is an occidental production system and it is an administration way that emerged to keep away from waste due to production inputs and outputs. So, redundant anything for production are removed and according to the standard, amount, quality, and persistence are ensured. It is an accomplished combination of lean production, mass production, and craft production. Quality and elasticity are important here (Çelikçapa, 2000). Craft production, using very able to employees and basic and elastic tools, realize client's request. However, their costs are high as they cannot provide economies of scale. Mass production utilizes unqualified or part-qualified employees and automatic machines. This reduces the cost of the products but it loses on product variety. In lean production, at this stage, it takes the good sides of both and moves away from the bad sides. A lean production is a production approach that makes good and high production by using the least time, place, material, and labor force (Chen, 2017). According to what is inscribed up, firms need to find an answer to the following question. 'For lean production, how do we realize the same as the client request, with the less waste, the least time, low cost and unmistakable production, utilizing the less resource, and utilizing the production elements flexibly, making benefit of the whole of their potential?' (Okur, 1997).

Lean production and conventional mass production are dissimilar to each other. While conventional production focalizes on the inventory of a system, lean production, on the contrary, disagrees with it. The presentation of lean production in all kinds of sectors has a direct effect on the production process (Gupta and Jain, 2013). Lean production uses less sources than conventional mass production. It offers a diversity of products at high quality and low cost (Marodin et al., 2018). In conventional mass production, cost, and provision times are loud. Therefore a great number of production takes place. But in lean production is not this issue, there are its little-batch productions (Rother and Shook, 1999). In lean production, the term 'lean' is lean because it utilizes lesser of anything than conventional mass production. Thus, by the concept of less is meant, for example, using half-and-half of the production area, using half-and-half of the plant workers, using half-and-half of the investment in vehicles, using half-and-half of the endeavor, and using half-and-half of the engineering times utilize to improve a novel product in half-and-half the time (Womack et al., 1991; Melton, 2005; Wahab et al., 2013; Sheikh Sha Alam et al., 2019). The lean of production means to produce a good output and provide a little input to reach the purposes of a firm. What is called 'input' here represents the amount and cost in source utilization. The 'output' represents client feedback on the amount and quality of a product vended (Wahab et al., 2013). Lean production provides for improving production operations and increasing the workers business pleasure (Singh et al., 2010). Lean production concentrates on the decrease of delivery time and, inventory, the request should become extra steady (Carvalho et al., 2017). In addition to lean production, lesser endeavor, and area use, it is to generate the identical and more according to mass production not a novel inventory, with good quality with little defects (Paranitharan et al., 2011; Dutta and Banerjee, 2014). There are dissimilar purposes for the practices of lean production. For example, complete removal of waste, the fulfillment of client wants, and utilize lesser endeavor while producing at the identical ratio of production (Dutta and Banerjee, 2014). As seen on Table 1.1, the comparison between mass conventional production and lean production is explained by Womack et al. (1990).

Table 1.1. Comparison of Mass Conventional Production and Lean Production

	Mass Conventional Production	**Lean Production**
Foundation	Henry Ford	Toyota
People - Production	Unqualified or qualified employees	Teams of very qualified employees on whole grades in the business
Thought	Purpose is ‘fine sufficient’	Purpose is perfection
Organizational thought	Hierarchic and administration receive liability	Value streams utilizing suitable grades of authorization
Production techniques	Provide loud quantities of standardized products	Provide products which the clients have requested
Equipment	Costly and one aim machines	Manual and automatic systems that would manufacture big capacity by wide product diversity

Lean production is applied for a firm to heal performance efficiently in the lengthy run (Negrão et al., 2017) and lean production applications are important for a firm’s operational competition (Dües et al., 2013). In general, lean production is accepted as the most used form of production. When we look at the literature, it is revealed that there is a positive relationship among operational performance and lean production practices (Marodin and Saurin, 2013; Tortorella et al., 2017). In other words, production processes enable lean production applications to eliminate waste, ensure activities that add value to the client, and with this, operational healing (Shah and Ward, 2003). For lean production applications to be accomplished, it is necessary to generate, design, and pack products in a retrospective and forward-looking manner, that is, backward to suppliers and forward to clients, in order to provide peripheral and operational purposes (Dües et al., 2013). If lean production applications are adopted, firms around the world healing their operational performance in their processes (Chavez et al., 2013; Wickramasinghe and Wickramasinghe, 2017).

The application steps in a lean production should be as follows. As a first step, waste must be identified in a production system. Firms want to know the hidden or not hidden waste in their systems. These wastes are of dissimilar kinds. It is necessary to know the kinds of waste and the reasons for its occurrence. Because lean production trusts in finding these reasons and improving the problems permanently, it uses several tools to decrease or remove such waste. The next step is to discover the basis reason resolution. Fundamental lean notions and reasons should be determined. However, seeing the reasons may not be the resolution. Therefore, it is necessary to determine the impacts of the resolution on the whole system. The last step is to discover resolutions and test them. These resolutions must become applied after the testing phase. In general, education and follow-up are significant in all of the steps described upstairs. Endurance is required because the application steps can receive a lengthy time (Gupta and Jain, 2013).

Production firms and the production sector that rely on production face difficulties other than peripheral and economic pressures. They want the need to decrease or remove overproduction. Firms are faced with requests from competitive markets to protect their productivity and competitiveness and to use innovative production tools. Using lean production applications, strategic and operational steps are designed and improved to decrease waste and use their sources efficiently (Shah and Ganji, 2017). In addition, lean production applications have been adopted to compete in the global market (Nasab and Zare, 2012). Adopting lean production is to manage strategic and operational winnings in decreasing waste. Researches in this field have stated that in order to be in a competitive environment and keep this in equilibrium, firms need to decrease the delivery time and product design to create a high quality and good production infrastructure, and this decreases the associated overproduction and waste (Womack and Jones, 2006). Lean production would solve the economic problems of a firm. These solutions produce products with lesser capacity and offer products faster than traditional mass production products. Thus, when meeting client's requests, productive process management is realized with low cost and waste. With suitable and true procedures and applications, lean firms provide managers to take more comprehensive corporate purposes and utilize existing data for these purposes and considering market requests, resulting in reduced delivery time, inventory grade, waste, and overproduction (Shah and Ganji, 2017).

Having production authority reveals advanced job performance and it provides the abilities of producers to apply a job tactic, according to the product market (Schmenner and Vastag 2006; Schmenner et al., 2009). With the increasing competition, firms began to discover lean applications, considering that a quality factor solo will not create a significant and sustainable job performance (Corbett, 2011). Kennedy et al (2013), stated that although it is a lean approach that reduces waste and offers value, the area of practices of lean tools has been used more in the production sector. In the past decade, producers in the growing nations like India and China have been striving to make their production, at low cost, high value, flexibility, and productivity than 'Fordist production', using lean production applications (Jadhav et al., 2014). According to Jassim (2018), a lot of firms see lean production as a significant application to increase the quality of services and products and to gain a competition benefit in the global market. The rules regarding the adoption of a lean production system in a firm are as follows;

1. Rule: This rule is, how humans work, is looked at. Whole actions in a firm should become certain because of series, contents, timing, and conclusions.

2. Rule: This rule is linked to communication problems. Looking at a relationship or communication between the client and the supplier, this communication should become open while forwarding a demand and receiving an answer.

3. Rule: This rule is, what is mainline of a production process, is looked at. The path to products and services should become accurate and basic.

4. Rule: This rule is linked to healing. Healing is scientifically appropriate and performed by an instructor at the under grades of a firm.

Hines et al (2004), have explored the growing of lean production from the beginning and over the years and they said that it is a production philosophy rather than a mode of production. The effect of lean production on firms has resulted in firms accepting these practices beyond their own limits. Thus, firms have used lean production applications and tools, whether in product improvement processes or in a supply chain. There are two causes given for the start of lean production. Firstly, high demand from clients, and secondly, very developed production system (Jasti and Kodali, 2015). Accordingly, as the lean concept is used in the production sector, it has been accepted by everyone that it is important for management to develop the performance of a firm (Bortolotti et al., 2015). The basis of lean production is the removal of the whole waste happening in the firm. This reduces the time among giving an order and shipping the ended products to the client and raise fruitfulness and decrease production costs (Rewers et al., 2016). Lean production ensures regular, fast streams of knowledge and products throughout the value chain (Levy, 1997). Lean production supports raise job volume and decrease the quantity of transition. This is important in ensuring efficient (Thurston and Ulmer, 2016). Firms that apply lean production want to increase efficiency and effectiveness (Womack et al., 1990). Firms gain higher effective in raising product value and quality from the view of the client (Marodin et al., 2018).

Lean production ecosystem is an obligatory philosophy for the valid script of ambiguity (Holweg, 2007; Kumar Singh and Modgil, 2020). In the researches, it has been revealed that firms using lean production applications prevent pollution at a great grade (Rothenberg et al., 2001; King and Lenox, 2001). Because lean production also increases the efficiency of sources as it reduces energy spending and material usage and finally, tries to prevent peripheral pollution (Rothenburg et al., 2001; Larson and Greenwood, 2004). Melnyk et al. (2003), stated that if there are firms that manage to reduce their inner waste with lean production applications, they will apply good peripheral administration.

Consequently, production firms face competition, excessive operating costs, and operational issues around the world, and these firms have made significant endeavors to adopt Japanese production applications (Wu, 2003). Schonberger (1982) and Hall (1983) discuss that what the Japanese in fact, do is improve a novel strategy for the production industry. Lean production is not just about discovering mistakes, it's about stopping them (Shingo, 1989).

1.2. Identifying of The Lean

The lean notion has been revealed by the Japanese producers, particularly by the Toyota Motor Corporation, or TPS (Shah and Ward, 2007). The term ‘lean thinking’ was presented from Womack and Jones (1996) in their comprehensive research from Toyota’s Healing Systems. The lean notion has become extensively utilized in production sector (Cua et al., 2001; Shah and Ward, 2007; Wee and Wu, 2009; Jonsson et al., 2011; Guerrero et al., 2013). But the lean is practicable in any sector, production, and service (Stone, 2012; Mostafa et al., 2013). The effect of lean thinking qua a tactic for the supply chain and not only production is significant and has gained much attention of and academia (Farah, 2015). Today, lean thinking has become used in a lot of another country and a lot of another sectors (Meng, 2019).

Lean is a business philosophy that describes the tools for defining and eliminate whole kinds of waste, reduce variables from request to supply, improve production processes, and optimum state (Shah and Ward, 2007). Here, in relation to the removal of waste, if inventory grades drop, and there is an unregularity in the material stream, this unregularity is close linked to its elimination without causing stream (Liker, 2004; Richen and Steinhorst, 2005; Bhasin and Burcher, 2006; Abdulmalek and Rajgopal, 2007). Lean provides high productivity development processes, low cost, and non-waste. Therefore, from a client perspective, actions that do not add value are removed to decrease costs, develop quality, and raise the elasticity (Womack et al., 1991). Lean is utilized more in an endeavor to work to form higher values for the client with doing source usage higher productive (Kayanda, 2017). An important point of the lean concept is to concentrate on value. In general, it highlights improved performance and removal of specific actions, connected whether they adding value and not. Therefore, it is the client who determines whether something is Muda or not (Anđelković et al., 2016). According to the Lean Enterprise Institute (LEI), the central opinion of lean is to increase client value when reducing waste (LEI, 2018). It is considered a lean antidote. Lean thinking offers ways of defining value, sequencing value-creating steps in the best, and correct way, eliminating those steps or activities when necessary, and performing them with increased efficiency (Womack and Jones, 1998; Thangarajoo and Smith, 2015). With lean, the road to optimum operations is to determine the stream of value and whole activities taken to ensure products and services that add value and do not add value to the client (Trojanowska et al., 2011). In other words, lean thinking is lean as it makes it possible to produce more by spending less and less labor force, equipment, materials, time, working hours, labor and space, to produce competitive products, and to provide added value to clients and to get closer to the actual expectations of clients (Krafcik 1988; Womack and Jones, 1998; Womack and Jones, 2003; Liu et al., 2013; Jedynak, 2015). Lean thinking aims to ensure that the process from the raw material that is the source of the product to the end-user is without disruption and creates value. In other words, it is aimed to increase the profitability of firms by reducing costs together with the elimination of waste, increasing client satisfaction, gaining elasticity according to the market situation, and accelerating cash flow in all product and service creation steps from design to delivery (Ertuğrul et al., 2013). The purpose of the lean concept is to form higher value to the clients at a low cost (Myerson, 2012).

Lean is accepted qua productive thought to develop a job in nowadays's competing world (Shaıkh et al., 2020). The best pop method of constant healing is lean. If a firm determines to apply lean, the firm's primary center is on how to decrease waste and be higher productive (Prasetyawan and Ibrahim, 2020). According to Olesen et al. (2015), lean thinking is a tool that allows a firm to be higher productive at the velocity and stream of production. This is whole regarding reaching operational perfection and sustainability. Increasing value in an enterprise will ensure whole personnel with the correct encouragement to raise an enterprise's productive and general fruitfulness (Castillo et al., 2015; Wiese et al., 2015). The client seeks excellence. Lean is a systematic tool that aims to identify and eliminate activities that do not add value to the product thanks to constant healing with follow the product (Farah, 2015). The accomplished implementation of lean has ensured a series of firms to develop their underside limit with gain. With the lean practices, potential aging causes are eliminated, it implements fewer inventory levels based on JIT production, eliminates rejects and junk formation, minimizes use waste for inputs, and has been efficient to improve resource management (Das, 2018). The researchers specified that the purpose of lean is excellence which is mirrored with raised productivity, reduced errors and inventories, and raised product diversity (Abdallah et al., 2019).

Researches generally describe lean as an administration system created with two grades of abstraction. These are strategic and operational grades (Hines et al., 2004; Shah and Ward, 2007). The factors of the strategic and operational grades of lean are very connected, creating a combined socio technic system whose principal purpose is to remove waste at the same time decreasing supplier, client, and inner variables (Shah and Ward, 2007). The principles are the component of the strategic grade and they symbolize the goals and policies of the system, like describing value from the client's view, describing and providing value flow, removing whole types of waste, production according to the draw of the client, and constant stream production (Womack and Jones, 1996). A few research has specified the positive relationship among lean and measurement of operational performance, like quality healing (Dahlgaard and Dahlgaard-Park, 2006; Karim et al., 2008, Netland and Sanchez, 2014; Negrão et al., 2017) and turnover of inventory (Demeter and Matyusz, 2011; Yang et al., 2011). Lean applications are generally accepted qua a tool to develop firms's operational performance (Shah and Ward, 2003). Lean applications are factors described at the operational grade were utilized to operationalize lean policies and transform them in every day, on place duties (Marodin et al., 2017).

The fundamental characteristic of the lean strategy is to decrease all kinds of waste available in the production stream. These are waste of material, waste of time, or waste of action (Rossini and Staudacher, 2016). The focalize of the lean become on the waste minimization utilized for raising real value-added (VA) activities, meet client requirements, and protecting gains. Lean provides for cost decrease and elasticity, as already available products, thanks to constant removal of waste, and NVA activities along the chain (Govindan et al., 2015). Lean is a systemical and combined administrative way essentially goal on removing waste and unproductiveness in an operation, which, to reach the top probable performance, requires to become expanded to whole operations in the focused firm and, if probable, between clients, and suppliers (Danese et al., 2012; Danese et al., 2018). Wee and Wu (2009) achieved that the name lean involves a sequence of actions and resolutions to remove waste decrease NVA activities and develop VA activities. Lean applications make proactive actions to eliminating whole kinds of production operations wastes and prevent or decrease the costs of mismatch (Das, 2018).

The lean notion concentrates on the firm's constant healing with reducing outgoings thanks to providing zero production errors, having little inventory grades near to zero, and becoming unlimited product diversity (Abdallah and Phan, 2007; Sukwadi et al., 2013; Carvalho and Azevedo, 2014; Alhyari, 2015). The purpose of lean is to manufacture products and services of more quality with a low cost and in less time with reducing wastes (Dennis, 2007). Lean increases and provides flexibility in shortening the delivery time, having low operating costs, improved quality, low stock level, and meeting client demands (Zimmer, 2006). Lean processes decrease costs for the purpose to utilize less sources and to produce lesser waste per monad of production than production with the conventional methods (Forrester et al., 2010). Rymaszewska (2014) stated that lean is to become considered qua an administration system that gives the top results with a lengthy-period. In the brief-period, very powerful gain winning might become shown.

Lean applications have become determined to develop production and firm performance. The applications are aimed to reach a lot of purposes for a firm, especially to develop client sensitivity through constant healing and description or removal of whole kinds of actions and operations that do not adding to client value (Davim, 2018). The lean is a result of production managers accepting the significance of client's pleasure and the requirement of answering quickly to client's wants (Houshmand and Jamshidnezhad, 2006). For instance, with a questionnaire made by the EEF Productivity Survey (2001), it is observed that approximately 50 percent of United Kingdom-situated firms used a lean concept into some section of their generation plants. Referring to the IW/MPI Census of Manufacturers (2007), approximately 70 percent of producers in the United States has performed a lean concept aimed at operational healing (Thangarajoo and Smith, 2015). If accomplished applied, the lean concept lets to good usage of production sources and waste minimization (Martínez-Jurado and Moyano-Fuentes, 2014; Pampanelli et al., 2014). Though Japanese firms have utilized the lean concept onward 1950, it becomes observed that it got to become pretty accomplished when it started to become used regularly, combining, technologies, tools, operations, and people (Dal Forno and Forcellini, 2012). As a result of their studies, Ilkım and Derin (2016), argued that in order for the lean philosophy to be applied effectively in a firm, first the managers and then all the personnel should be trained. Because lean management understanding can only be achieved by organizational culture change.

Lean becomes defined of a lot of directions like a philosophy, a shape of thought, an operation, a series of factors, a series of tools and technics, a touch, a notion, an application system, a schedule, a production model (Vanichchinchai, 2019). Pakdil and Leonard (2014), removing waste low changeable production costs connected by labor force, materials, and power, so increasing the monad profit of products. The main center of lean is at removing actions that do not added client value and handling VA activities (Wee and Wu, 2009; Duarte and Machado, 2017). Therefore, lean thinking is concerned with the elimination of waste and processes, which is called 'Muda' for products and clients and is about implementing lean production tools and reducing costs (Waring and Bishop, 2010; Liu et al., 2013; Arif-Uz-Zaman and Ahsan, 2014). Lean applications are to eliminate the waste of the operations and do the operation higher active and productive with lower price and to ensure high pleasure to the clients get competing benefits (Monden and Minagawa, 2016). The firms are compete in the dissimilar sizes of performance to reach lean purposes. These sizes of performance involve quality, delivery, cost, and elasticity (Gunasekaran and Ngai, 2012; de Sousa Jabbour et al., 2014).

Lean thinking is an administration and job strategy method that aims to streamline the production flow (Womack and Jones, 2003). It decreases costs and delivery times by identifying and eliminating waste and providing the client with fully what they need, when and in whatever amount (Womack and Jones, 2016; Ferreira et al., 2017). The usage of the lean notion indicates that the operations are designed to become to reach an optimum stream of materials and knowledge in a minimum (Czarnecka et al., 2017). Lean assists firms to raise productivity, develop quality, decrease cost, develop client answer time, gain profit, and improved public image (Verrier et al., 2014). Also, lean provide to elasticity, reducing of stocks, and developed grade of service (Kazmane, 2018). Lean applications ensure pollution decrease thanks to their natural touch to removing waste. With lean, the cost of ecological administration is decreased, which provides to the removal of obstacles to pollution minimization preventions that conventionally done thought costly (King and Lenox, 2001). Lean might assist firms to embrace ecological administration applications that purpose to decrease pollutants and waste (Yang et al., 2011).

Lastly, in short, lean can be summarized as follows; Continually describing and concentrating on client's values; adjust the goal of center and support operations around ensuring these client values; providing the whole enterprise is concentrated on endeavors to promote the optimization of these operations with eliminating wastes; constantly developing the basics needed, like improving quality abilities, strengthen teams and person, and establishing inter-agency relations; improving system-across understanding to constant healing (Hu et al., 2015).

1.3. Lean Principles

Lean principles provide high-performance giving products to the last client rapidly, by the least quantity of waste and unproductiveness and forming the best potential value to stakeholders (Wiese et al., 2015). It purposes to grow efficiency by removing wastes from systems and processes in aspects such as people labor, inventory, waiting, and by getting enough output from less input (Liker, 2004) and provide zero errors in the layers separating the organization construction. The layer separation is made by the stepwise application of lean production tools (Åhlström, 1998). Antony et al. (2012) said those lean principles, like constant healing, results in efficiency growth. A lot of firms in the world are utilizing lean principles to develop product quality, decrease cost, and raise client sensitivity (Govindan et al., 2015). Lean management has five unique principles. These are signify value, determine the value stream, perform the value flow, apply pull-based production and tracking for perfection constantly (Emiliani 1998; Murman et al., 2002; Hopp and Spearman, 2004; Spear 2004; Dutta and Banerjee, 2014; Shaaban et al., 2015). These are as follows.

1.3.1. Signify Value

Value is defined qua what the client is wanting to payment for and it is described by the client. For instance, can become the operations of converting the product like assembling and machining (Tran, 2016). It leads businesses to appraise who is their real clients, and what these clients regard qua value. This principle highlights to describing value from the way a client senses it, with the client finally deciding the value of the product and service (Womack and Jones, 1996; Raman, 1998; Lian and Van Landeghem, 2002). So, it is to rethinking value from the view of the client (Womack and Jones, 1996). While the value of products and services is determined by clients, it is aimed to eliminate waste and actions that do not add value.

Describing client's value is significant to reply to the following questions: What does the client need?; When and how does the client need it?; What combination of characteristics, abilities, validity, and price would become choose for clients? (Čiarnienė and Vienažindienė, 2012). Producers require to understand who their clients are. Today, producers do the error of production that they are appropriate for production, rather than concentrating on production products that their clients value. Hence, producers are encountered with improving a variety of products linked to comprehension of the wants of clients, assisting to fulfill the lean principles (Womack and Jones, 1996).

1.3.2. Determine the Value Stream

The Value Stream includes the whole of the required activities and operations to provide value to the client. The full value stream streams along the whole supply chain, of raw-materials to completed products (Tran, 2016). There are two opinions. The first a concentrated opinion on the value-added activities, referring just to the particular actions included in added value to the form of a particular product and service in a firm, the second opinion involves the whole actions required in the firm (Hines et al., 2004). This principle makes to push firms to: Examine and describes the whole the actions included in forming a product; Define actions that adding-value and remove activities described qua waste in a value flow (Duggan, 2012). Value Stream Mapping (VSM) is a means suggested to define actions in a value flow adding value in and among a product conversion operations and map an optimum value flow (Womack and Jones, 1996; Brunt, 2000; Singh et al., 2011). Value stream map utilizes illustrated to reasonably represent the valid status of a value flow before whole the healing preventions and later status of a value flow future the aimed healings are done (Nash and Poling, 2011). Emiliani (1998) stated that the action of eliminating wasteful actions in a value flow can help optimize the job operations and raise a firm capacity. Bozdogan (2006) told that by the removal of wasteful actions, not just a firm might decrease the production costs, but also can raise the fruitfulness of the firm and develop in brief and lengthy period. The value stream is regarding the model and design of the production systems, containing improvement of product, request meet, and suitable production, particularly for the purpose of selecting preventable waste actions (Womack and Jones, 1996). The value stream means that the raw material transforms into a product and includes all the stages from one producer to another producer and end-user. Value Stream Management includes the processes of measuring all interacting businesses, developing and understanding the flow in order to provide competitive power in terms of service, quality, and cost, elated to the products and services of the firm (Keyte and Locher, 2004). It describes the whole value flow to every product and family of product and removes waste (Womack and Jones, 1996). Further, three principal kinds of actions are seen in the value stream: VA activities; NVA activities but cannot become prevented; and not added value activities and must so become removed (Čiarnienė and Vienažindienė, 2012).

1.3.3. Perform the Value Flow

The value-forming stages and operations must become done to stream without lag and deduction. It is told that require must work to prevent the run of a one-duty operation at big lots (Tran, 2016). Having a client pull the product at any time instead of pushing it will eliminate the source of waste. When the constant stream is applied, product development, order taking, and physical production works will be completed in a very short time. This allows designing, plan, and produce exactly what the client really wants. Making sales forecasts, organizing campaigns to push out-of-stock products, and using complex computer programs will remove the hassle and only the desired things will lead to better production (Enstitü, 2007). This principle utilizes to reduce lots and tails and decreasing lags on actions that adding value and decreasing the NVA activities (Shah and Ganji, 2017). It while providing regularly the shortening of delivery times, includes essentially the process of single-part stream, rather of a stream using of lots (Womack and Jones, 1996). First, it eliminates obvious waste in a value flow, then flows to the remaining value-adding operations (Thangarajoo and Smith, 2015). Lian and Van Landeghem (2002) explained that the fundamental notion of the value flow is to do pieces single part at a time from raw materials to completed products and to transport them one by one to the following job station with no wait time in among. The flow in a value, improvement operations where the ingredients of an ultimate products must become in a continuous and hassle-free movement from station to station without deduction and less wait time in among with the reaching zero inventory among the value improvement operations, a fruitful movement working in operation rapidly and regularly, removing sub-optimizing all-duty groups that are not conducing to the final throughput (Howell and Ballard, 1998; Raman, 1998; Dettmer, 2001).

1.3.4. Apply Pull-Based Production

The fourth principle, pull, refers to the attraction of value by the client. As in traditional production, there is no need to produce in stocks and then organize campaigns to sell the remaining products. By applying this principle, the product requested by the client is produced and the pull process starts from the client. This principle of pulling continues within the factory and continues until the last supplier. Thus, there is no need to keep stock. Production plans are not prepared for machines, and the entire supply chain produces only what the next one wants (Sultanov and Özçakar, 2010). This principle indicates that the client pulls the product from the production as wanted on the contrary than the production pushing products, generally unneeded, on the client (Womack and Jones, 1996). It highly removes overproduction by focusing on just what clients want. It reduces time and waste, providing the supply chain to become clear so decreasing ambiguity (Shah and Ganji, 2017). The production must become according to order. The production operations must become provided once the client needs to buy, not while the suppliers want to ensure (Tran, 2016). Womack and Jones (1996) described the notion of pull as no person generates a product and service before the client has demanded in the downstream market. This principle is actually in opposition to the conventional push system in production. In the case of an incorrect plan to arrange job stations, actions can reason the backlog of inventory among job stations or job stations idle waiting for pieces. But, pull guarantees a constant stream in the production operations by connecting real client orders with the production ratio. The upstream process in a value flow responds just to the request put forth with a downstream process (Groover, 2010). For instance, production pieces are transported to the after job station just when pieces are demanded by the next job station. Womack (2002) specified that a really lean structured firm requires to include the pull notion in their operation in providing no waste with time, funds, and endeavor is done. Also, Cook and Graser (2001) emphasized that, for making a pull production operation to operate accomplishing, important cooperation by clients is needed to get their wants and expectancy, and suppliers to provide essential material is fulfilled in according with the request. The pull system is installed and applied by utilizing Kanban, which are physical or electronical devices to transfer the requirement for pieces and subassembly of a place in the operation to the previous one (Čiarnienė and Vienažindienė, 2012).

1.3.5. Tracking for Perfection Constantly

The last principle of lean is continually tracking perfection. Refersing to Emiliani (1998) by the application of the initial four principles, firms be struggled for perfection as the actions in a value flow be high transparency than previous. Refersing to Womack and Jones (1996), Gupta (2015) said that this principle supports administration to constantly discover the novel occasions for healing emerged from tracking the four principles as it is not last to the endeavor of decreasing endeavor, time, area, cost, and errors in a value flow (Tran, 2016). It purposes at creating the thought between lean believing that waste removal in a value flow is a constant operation. This principle fundamentally involves that firms require to continuously renew their road by the four principles till whole the NVA activities and wastes are eliminated from the value flow (Mann, 2009). By this principle, the culture of continually exploring occasions to develop operational productivity, decrease costs, and develop the quality of the product has emerged in a firm (Thangarajoo and Smith, 2015). This notion is not entirely on quality but it involves, production what the clients need, at the correct time, at the correct cost, and by the least waste (Womack and Jones, 1996). It means that the healing cycle needs to become constant and it must definitely not finish (Melton, 2005). It is wholly relating constant reducing of waste and increasing of value, so, constant healing (Womack and Jones, 1996). Perfection needs continuous effort to satisfy the client wants and develop a person’s operation by zero errors. As that occurs more and more stratum of waste be apparent and the operation proceeds to the theoretic finish spot of perfection, where each activity adding value for the final client. This is the belief that healing endeavors are nothing ended, and it is the consistence to hold the discipline for healing in the location (Kaizen) (Čiarnienė and Vienažindienė, 2012).

1.4. History Development of Lean Production

The historic advancement of the notion of lean for lean production and related practices is a significant issue (Fernando and Cadavid, 2007). The future of the production sector is lean production. Lean applications are also the top way for producers to raise their competition in the world (Kumar and Vaishya, 2018) and accordingly, lean production has become the most used word in the production sector (Pavnaskar et al., 2003). Lean production is a series regarding technics and processes created by Toyota engineers. It is pop for removing waste and rising product value for firms in the world. The source of lean production is located in Toyota's Japanese firms (Pavnaskar et al., 2003). The source of lean production is located in Toyota's Japanese auto firms and it was created from TPS (Pavnaskar et al., 2003; Nordin et al., 2010). The Japanese, and Toyota in especially, made attempts to develop and improve the lengthy production phases for each aspect of their processes to reduce waste (Thompson and Mintz, 1999).

The lean production notion started in Japan later in the Secondary Globe War. This notion emerged if they saw that Japanese producers did not have a large investment themselves to construct facilities like these found in the United States (Pavnaskar et al., 2003). Lean production has manifested itself in Japan with the proliferation of mass production in the United States (Dehdari, 2014). The Japanese automotive sector at first started to grow in 1980, thus surpassing United States manufacture. By the growth from the Japanese sector, the notion of lean production did present by John Krafcik, a student and searcher in the International Motor Vehicle Project (IMVP) laboring over the world auto sector at the Massachusetts University of Technology (Cusumano, 1992; Bhasin, 2015). Basics of lean production was firstly asserted in the 1950s by the Elji Toyoda and the Toyota Motor Firm (Liker, 2004).

The notion of lean production did start in Japan, and the TPS is the initial to utilize lean applications (Gupta and Jain, 2013). First Japanese pioneers like the Toyota Motor Company's, Taiichi Ohno, Shingo, and Eiji Toyota produced operations-focalize production system. The purpose is to reduce the spending on sources that add not value on the product (Kadam et al., 2012). Sakichi Toyoda and his sons were the originators of the system: Sons names are Eiji Toyoda and Kiichiro Toyoda. Also, the other name is engineer Taiichi Ohno (Durakovic et al., 2018). Sakichi Toyoda was work in the textile sector. Here he made a handloom by special machinery for stopping the machine if the yarn rupture. This gave rise to the Jidoka tool. Kaichriii Toyoda traveled to the United States in 1929 where he was affected by the Ford production system and started to implement the methods he ascertained (Dekier, 2012). Taiichi Ohno was a production engineer of Toyota in 1940 (Melton, 2005; Dehdari, 2014), and he requested to add value for clients by lesser waste and bigger yield instead of pop mass production (Dehdari, 2014). Gupta (2011) stated that since lean production has been accepted by Taiichi Ohno since the 1950s, it is intended to decrease waste in whole processes and stand out in the area of process healing. Lean production kept going its healing in recent 1980s with the advancements in the network (Melton, 2005). Finally, Taiichi Ohno advanced the TPS. His purpose was to satisfy client requests efficiently. Toyota was reducing stock and funds for a product and allowing products to be manufactured in little lots. He also thought that investment in people did extra significant than investment in large production dimensions. Therefore, by providing orderly education to employees, they are eager to make a higher contribution to firms (Dehdari, 2014). By lean production originated in Toyota, it responds to the faster request by rapidly changing one production model from one to other. Thus, more efficiency is provided (Drew et al., 2004). It focalized on waste minimization to raise the adding value to meet the client's requirements and protect gain (Carvalho et al., 2011).

Japanese firms had an important place in the auto production industry in the world, thanks to TPS, with a quality product, cheap price, and JIT system in the 1980s (Prasad et al., 2018). The reason for its 'lean' name is that lesser people energy, area, cost, time, and material are utilized in the Japanese work process (Kadam et al., 2012). The productivity and quality healing applications used by Toyota in production systems were introduced as lean production in the book called 'The Machine That Changed The World', printed by Womack et al. in 1990 (Prasad et al., 2018). TPS is the second largest system in terms of efficiency after the mass production system developed by Henry Ford. Hence the development of lean production is seen as a continuation of the development of Toyota. Lean production started to be recognized with the mention in the 'Machine book that Changed the World'. This book includes benchmarking datum on the new touch improved by Toyota after the Second World War to indicate that it is a good direction to arrange and administrative client relationships, supply chain, product improvement, and production processes. It is called 'lean production' as it generates more and more with reducing sources. In their following edition, Womack and Jones told over the five fundamental principles of value, value stream, flow, pull, and perfection in their book 'Lean Thinking' (Womack and Jones, 1998).

It is also known as lean production, JIT, TPS, Stock-Less Production, Material as

Needed, Continuous Flow Production, and Zero Inventory Production Systems after the book named ‘The Machine That Changed the World’ was written (Russel and Taylor, 1998). Since firms that adopt lean production have quality and cost benefits compared to other conventional mass production firms, this lean production has become widespread (Fleischer and Liker, 1997).

1.5. Purposes of Lean Production

One of the main purposes of lean production is to realize a constant stream of raw material to finished products and to the client (Sheikh Sha Alam et al., 2019). Also, it provide to produce quality products economically and efficiently in accordance with world standards, to meet client requests, to decrease inventory, a decrease of time to the market place, decrease human labor, decrease cost, decrease delivery time, decrease waste of production, constant healing for reduce of waste, raise fruitfulness and quality (Karlsson and Åhlström, 1996; Okur, 1997; Todd, 2000; Chen et al., 2013). These purposes show the performance of a lean production (Wahab et al., 2013). Lean production, maintaining competing power in the market, understanding the wants of the client, and determining the process that satisfies their wants are among its other purposes (Shah and Ganji, 2017). There are two principal purposes to remove waste at each step of production. The first is to not keep stock on the basis of raw materials, semi-finished products, and products, it means zero inventory. Second, the manufactured product and the part and the purchased product are the absence of defects, it means zero defects (Tekin, 1999).

Lean production purposes will become categorized as follows. (**1) Removing of waste and defects;** actions that do not add value to the product and service, and the removal of waste, as waste sources spend time and area, is the purpose of lean production. Extreme inputs of raw materials, the occurrence of unnecessary errors, having an incorrect product that is not essential for clients, and cost waste related to their recovery are also included in this category (Capital, 2004; Prajapati and Deshpande, 2015; Shah and Ganji, 2017). In addition, it is carried out to ensure efficient use of people, to use the sources in the process efficiently, and to eliminate the actions and costs that do not have added value (Okur, 1997). (**2) The decrease of delivery time;** by shortening the delivery times, the reduction of the time for action results in a decrease in costs and waste. **(3) The reduce of total costs;** by reducing total costs, firms should generate at the correct price, time, and area for clients. This is a fundamental issue for firms. Therefore, firms must refrain from overproduction (Shah and Ganji, 2017). (**4) Cycle Time;** by reducing waiting times in a process as well as product transformation and process basing times, the production cycle and delivery times will also be reduced. (**5) Inventory grades;** in the production phase and especially Work in Progress (WIP), it is necessary to reduce inventory grade. It actually means low funds by keeping low inventory. (**6) Labor force fruitfulness;** By increasing labor force fruitfulness, it should be ensured that employees use their endeavor efficiently while working, that they do not deal with redundant work, and even if a work error can be prevented, these movements should not be made, and also the idle time of the employees should be reduced. (**7) Usage of area and equipment;** Production grade is raised high by making production with available vehicles and removing bottlenecks. By decreasing machine downtime, equipment and areas are used extra efficiently. (**8) Throughput;** The reasons why firms achieve large throughputs are by preventing bottlenecks, decreasing cycle time, eliminating machine breakdowns, and increasing labor force fruitfulness (Capital 2004; Prajapati and Deshpande, 2015). (**9) Elasticity;** The product variety becomes elastic with the least change costs and times (Capital 2004; Prajapati and Deshpande, 2015). It is also ensured that the production has the elasticity to reply to the client (Okur, 1997).

In lean production, it is ensured that whole actions performed, containing sub-industries, work in a combined manner as a team (Okur, 1997). Employees within an enterprise must move lean and have a lean concept in order to achieve success in lean attempts (Wong and Wong, 2011).

1.6. Core Concept of Lean Production

The most important components that distinguish lean production from other production systems are quality level, production balancing, low stock, factory layout, repair and maintenance processes, approach to workers, and near collaboration with suppliers, pull system, the problem solving and constant healing. For example, these components are components that complement and promote each other, like having a better quality level in order to work with less stock. These components are described in detail below (Sultanov and Özçakar, 2010).

1.6.1. Quality Level

Faulty products are prevented by the quality of the production process. As a production principle, quality process is achieved by using the ‘process and part error-free method’ and accordingly, quality production is provided. Quality is an important factor. Because, if defective parts are produced, the production line is stopped to correct this error. In lean production, the quality element is achieved in three different ways (Stevenson, 1993). The first is the design quality in the production process and a product. For this, all product procurement time and methods are standardized with experienced workers. The second is to encourage vendors to supply a good quality product in order to reduce defective parts and materials. If the seller is reliable, less time and cost is spent on the inspection of the incoming material. The third is to hold the workers responsible for producing quality products. For this, workers must be provided with suitable tools, equipment, training, fault finding, and quality measuring instruments. Also, when there is a problem, it is necessary to find and solve it. Here, too, there is a need for qualified workers (Top, 2001).

1.6.2. Production Balancing

Lean production ensures that the activities of a product from suppliers to final output stay in balance throughout the system. A purchase and production schedule is created to create a certain time frame, which is usually monthly. In Japan, Toyota dealers send monthly sales forecast reports for the products related to their market and for the next three months (Yasuhiro, 2004). With the monthly production plan, ‘how much production will be made per day?’, it is looked at this issue. The reason why daily production schedules are important in the TPS is that it is combined into the system with balanced production. In weekly plans, sales orders vary slightly (Sultanov and Özçakar, 2010).

1.6.3. Stocks

Lean production is called zero stock or no stock production for stocks. Excessive stock is seen traditionally as a solution when problems arise in factories. For example, if there is a malfunction in the machines, if there are fluctuations in demand, if the products are generated incorrectly, this can be met from the stock.

Lean production likens stocks to seawater and problems to rocks in the sea. Related to this, if the seawater decreases, that is, if the stocks are reduced, problems that have always existed but do not surface occur (Black and Hunter, 2003). Stocks are the cost of a factory. If the excess stock is kept, this is a factor that will take up unnecessary space in the warehouses and increase the costs of holding. Also, waiting for stocks adds no value to them. For example, the finished product, the product coming from the sub-industry, and the parts being processed can be kept idle in the firm. Stocks may be damaged or become obsolete by waiting. The ability to respond immediately to changes in the client's needs may be lost. If the stocks on hand are also consumed, competitiveness may decrease. All this creates waste. In this situation, with the supply and demand going in a balanced way, lean production can reduce stocks (Waters, 2003).

1.6.4. Factory Layout

In traditional production methods, the factory layout is arranged according to the needs of the process. In this order, machines performing the same task are gathered in the same place. Parts must move from one process to another. In order to process parts, they wait among the machines that do the same operation due to stocks. Moreover, these parts encounter a value-adding process in very little of their time in the factory. In lean production, the factory layout is arranged according to product needs. Thus, there is no stock surplus in the area, with similar products going through the same processes - such as assembly. Moreover, in traditional production, the movement of workers between machines was seen as waste in lean production, so this had to be reduced. Accordingly, Taiichi Ohno switched to Cellular Production in the 1950s to increase worker's productivity. Actually, Cellular Production had not been found by Ohno. It was discovered by American engineers in the 1920s, but with the applications of Ohno, Cellular Production has attracted attention (Russel and Taylor, 1998). This layout is called 'U-lines' as seen on Figure 1.1. U-lines are with one worker being responsible for many machines and providing a single piece of flow. The important feature of these lines is that the entrances and exits are made from the same place. Also, if there are fluctuations in demand, it is possible to comply with the changes by increasing the number of workers. The fact that a worker is responsible for many machines also reduces manpower. In the job division part, the same worker will do the first and last operation and tempo will be provided for the whole cell (Mike and Rick, 2001).

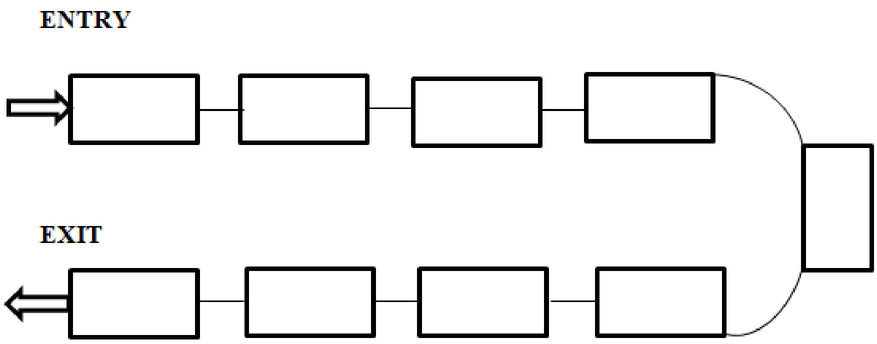

Figure 1.1. U-line Layout Plan

1.6.5. Repair and Maintenance

Machines in the factory may fail over time. Accordingly, the production also stops. If these machines break down, repair work must be done before they can be reworked. In addition, these failures are checked in advance and preventive maintenance is carried out by performing maintenance work at certain times (Kobu, 2003). In lean production, stopping production causes problems because less stock is kept. Therefore, in such a situation, preventive maintenance should be done more often to avoid repair work (Krajevski et al., 2007). From this, it is understood that lean production requires more maintenance than other production types. This is solved by the Total Productive Maintenance (TPM) tool. This tool is not a short-term process, but a long-term process with the participation of employees, which ensures equipment efficiency and enables the firm to change its culture (Smith and Hawkins, 2004).

1.6.6. The Workers

In the traditional production system, workers have variable cost characteristics. When demand falls, workers may be laid off as they are seen as variable costs. In lean production, workers have a fixed cost characteristic. Regardless of when the demand increases or decreases, workers are not fired. If there are idle workers, they are included in continuous improvement groups and trained and used elsewhere (Schemenner, 1993). In traditional production, workers are usually directed to a specific area and the limits of their duties are clear. But in lean production workers are versatile. This does not mean that the employees are experts in the subject, but they still have the knowledge and skills to solve this issue when it is encountered an issue. For this reason, necessary training should be given to workers in order to work in production (Stevenson, 1993).

1.6.7. The Suppliers

In lean production, low stock availability, timely delivery of the supplied parts are important in terms of quality and safety. Because when there is a shortage arising from the suppliers, it directly affects the production line. Also, in lean production, firms work with a small number of suppliers. Trust among suppliers is important and relationships with suppliers are long-term. There is no price-based competition. By cooperating with suppliers, the whole supply chain gains. Since there are relationships based on trust, firm information is given mutually and a situation is realized for the benefit of both parties. Here, long-term, daily, weekly, and monthly demand conditions are discussed and production is balanced. The stock level decreases and the costs decrease. In addition, since the material and raw material quality brought by the suppliers are known, it passes directly to the production line without being subject to inspection. Inspection is a process that does not add value, so time will not be wasted with this situation (Sultanov and Özçakar, 2010).

1.6.8. The Pull System

Traditional production uses the push system. The flow in the push system is as much as the manufactured parts that go from one production process to another as seen on Figure 1.2. In this process, the intermediate stock is used because it is ensured that the previous production cell is not suspended. To eliminate this situation, a plan is sent to each production cell, which makes it difficult to respond to changing demands (Monden, 1993).

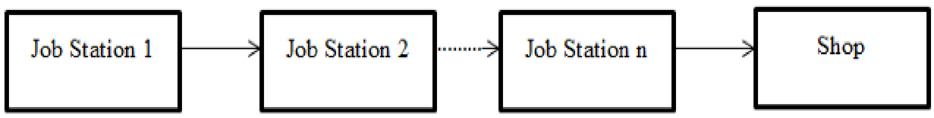

Figure 1.2. Push System

Lean production uses the pull system. In the pull system, the next process from the previous process is taken as many parts as needed as seen on Figure 1.3. The pull system starts with the client. Here, the final assembly line tells the previous process of how much product will be produced, and to the previous process produces the parts in the desired amount and time. In this way, there is no need to prepare separate production plans for each production cell (Monden, 1993).

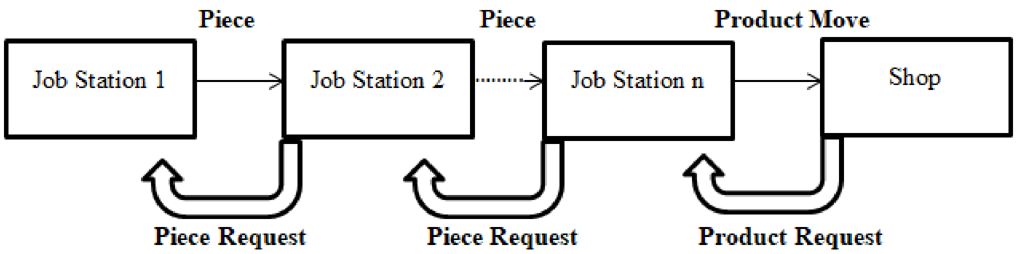

Figure 1.3. Pull System

Lean production uses Kanban instead of these plans. Kanban is used for production processes to produce at the desired amount and time. Kanban is important for lean production and is a card used to claim the required amount (Sultanov and Özçakar, 2010). In the pull system, production is pushed from top to bottom. The stream on the plant floor is operated by request from the downstream. This indicates that not material goes into processing downstream until there is a want. Traditional production has a batch-based system. In the pull system, the request creation steps start with the client, they form a request for the finished product, then the request is created for the assembly line, then for sub-assemblies, and this process rises along the supply chain. The pull system has an identical feature as the JIT. Because it is stated that the ongoing works and raw materials are given in on time and in the full quantity required by the downstream business process (Capital, 2004). The pull system does just exchange the client consumes, providing a check of source stream, and reducing waste. Also, it removes waste sources (Shah and Ward, 2003; Perez et al., 2010; Antony et al., 2012; Campos and Vazquez-Brust, 2016; Marodin et al., 2016). The notion of pull in lean production involves to reply to the pull, and request, of the client (Dutta and Banerjee, 2014).

1.6.9. The Problem Solving

Problem solving is an important element in lean production. Every problem is a chance to improve people and processes. With problem solving groups, productivity, and information flow increase. In addition, management is responsible for participating in and supporting lean production projects. If employees realize that management does not value working with them, they are discouraged and firm fail with lean production solutions (Puvanasvaran et al., 2008). Between employees are brainstormed and encouraged to solve problems. Sampling, quality control diagrams, statistical analysis, and control diagrams are used as problem solving methods (Stevenson, 1993).

1.6.10. Constant Healing

Constant healing is a perfect stream that removes the waiting time of employees and equipment, where the work is done by machine and physically, the ongoing works are constantly undergoing a process and the works do not stagnate. Here, among production processes is a little lot and one-piece stream, with products being processed without waiting. In constant healing, in production order, far from close workstations, a rapid movement occurs when semi-finished products pass from one production process to another. The purpose of constant healing is to determine the main reasons for NVA activities and to remove NVA activities with constant healing for production (Capital, 2004). With constant healing, a high grade of performance is achieved and good performance of little object emerges. The meaning of constant healing is near to the Japanese name Kaizen. The word Kai involves changing, while the word Zen involves the best. These words are accordingly described as change for the better (Jassim, 2018). Constant healing usually means optimizing work and it is an endless operation that keeps going to raise its serviceability. The best way to strengthen a firm’s foundation is to invest in people. People are a significant element for firms and it is significant that they are supported and developed by managers. Constant healing gives people courage and chance (Thurston and Ulmer, 2016). Constant healing aims to develop the relevant factors in the process of converting inputs into outputs (Stevenson, 1993). Constant healing appeals to a wide audience such as workers, suppliers, procedures, and equipment. Constant healing was introduced by Walter Shewhart and later Deming. This promotion is created under the name of the ‘planning, implement, control, and take action’ circle. It is also known as the Deming circle. The planning phase is the learning phase of designing measurable goals. The implement phase is the application process and the research phase of the required information. The control phase is the phase of examining this information appropriately. Lastly, take the action phase is the correction phase with future plans and quality methods (Dahlgaard et al., 1995; Gitlow et al., 1995).

1.7. Principles of Lean Production

Lean production principles are, in general, waste reduction, producing the correct product at the correct time, at the correct area, and with the correct quality, adapting to change, the efficiency of the value stream, quality, and constant healing (Kadam et al., 2012).

Liker (2004) introduced 4P and 14 administration principles for lean production. The first of 4P’s is the philosophy and this is a lengthy period of thinking. The second of 4P’s is the process and this is the minimization of waste. The third of 4P’s is people and partners and these are regard and expand them. The last of 4P’s is problem-solving and these are learning and constant healing. The 14 administration principles are as follows. **(1)** Administration decisions are based on a length period philosophy. **(2)** By providing a constant process stream, problems can arise. **(3)** By using the pull system, excess production is prevented. **(4)** The workload be balanced, is called Jidoka. **(5)** A culture of stop is created in order to solve issues and to apply quality correctly in the first. **(6)** Standardization duties and operations make workers and constant healing powerful. **(7)** Using the visual inspection tool, problems are not secret. **(8)** Tried and trustworthy technologies serve workers and operations. **(9)** To train managers who clutch a business, philosophy. **(10)** To improve teams and people who act according to the philosophy of a firm. **(11)** To assist the development of a broad network of suppliers and partners. **(12)** To go away and observe a situation in person to fully clutch (genchi genbutsu). **(13)** Making slow decisions with consensus, with all options in mind. **(14)** Being a firm that learns through always thinking and constant healing.

Liker (2004) stated that a few of the principles here can be applied and that there will become brief period healings into some performance measures in place of lengthy and sustainable healings. Administration decisions are based on lengthy period purposes, although this might result in negligence of brief period financial purposes. Once this is solved, it is probable to working with the other 3Ps, that is, to resolve problems, decrease waste processes, and improve personnel.

1.8. Benefits of Lean Production

The concept of lean is emerging to form equally dispensed processes and to decrease waste, affecting each part of the production process. Lean applications have both qualitative and quantitative benefits (Sheikh Sha Alam et al., 2019). The benefits of lean production are clearly seen in all factories around the world. Reports from firms about benefits are as follows. The decrease in cycle time, improvement in product quality, improvement in in time deliveries, reduction in on-going work, lower costs, advanced net revenues, decrease in inventory, improvement in workmanship, high production, rapid inventory investment entry, more elasticity, decrease in vehicle investment, improved use of the area, better ability development and work concentration and use of better machinery (Pavnaskar et al., 2003).

Lean production also provides the following benefits. The area is saved. There is a significant decrease in operating costs. Selling levels per worker rise. Quality check is provided. Profits rise at the achievement level. Sellings are doubled. There is little disappointment during a job. Constant healing is provided. There is a 70 percent reduction in operation tails. There is a 50 to 90 percent reduction in delivery times (Dutta and Banarjee, 2014). It provides a shorter delivery time. There is a decrease in dissimilar source kinds. High quality and raised fruitfulness are provided. Quicker decision making and problem-solving occur. A high level of client pleasure is provided (Čiarnienė and Vienažindienė, 2015; Siasos et al., 2017). Product waste is reduced. Workstream is reduced. The ergonomic size of a firm is increased. Work is reduced in process inventory. The sustainability part of a business is increased. The financial increase is provided (Durakovic et al., 2018). Also, if it is desired to benefit from lean production, it is provided by the change in the behavior of the firm. A good plan is required to adapt to changes. Otherwise, the firm may be in a difficult situation (Čiarnienė and Vienažindienė, 2012). Lean production provides the benefit of security and quality healing. Lean production practices develop production quality and create a safe environment for everybody. They also prevent the possibility of small errors in the applications and operations accepted for the work. Another benefit is that factories are provided with visual checks so that elements like raw-materials or tools can be monitored using lean tools such as 5S and time is reduced. If the other benefit, the sector, is working on lean, the change in the working culture begins here. With the labor force, communication raises, the sector’s sense of liability develops, and stress, endeavor, and tiredness decrease (Gupta and Jain, 2013). Junk and waste are decreased. It has the ability to deliver in time no anything lag. Transport distances are decreased. Abrupt closing of the machines is prevented. Production operations are kept in equalize according takt time. Storage spaces are well arranged, reducing time and human endeavor. Transition times are decreased. By using the pull system, it is protected from loud inventories. At an early time, faulty products are subject to inspection. Cellular production is applied to remove redundant transport and reduce costs (Siasos et al., 2017). Whole these kinds of benefits assistant the firm to win competing utility in the market (Čiarnienė and Vienažindienė, 2012).

Synergy is a significant benefit in lean production. Healing encourages a good changing in another space. This situation, even if the person does not intend to improve with the activity she or he takes, causes a big changing in the firm. Also, when talking about the benefits of lean production, individualistic healings such as how fine specific teams are working and how fine department is performing should be demonstrated (Sheikh Sha Alam et al., 2019).

1.9. Lean Production Tools

Firms have long begun to use techniques and tools to improve their processes efficiently. This has been reached by utilizing lean production tools and opinions. The lean concept is one of the strong administration philosophy of near history (Villarreal et al., 2016; Shah and Khanzode, 2017; Bellido et al., 2018; Parades et al., 2018). Many tools and techniques have been improved to decrease and remove waste (Green and Dick, 2001) and a lot of firms around the world use lean production tools in order to respond faster to clients, decrease costs, and develop the quality of the product (Govindan et al., 2015). Lean production tools have made firms higher competitive. By providing producers, clients, distributers, suppliers, and another stakeholders to think lean, it encouraged administrators to spread lean applications throughout the supply chain (Afonso and do Rosário Cabrita, 2015). Lean production tools purposes large-quality standard round the production process (Caldera et al., 2017). Lean production tools are combined in upstream and downstream actions and might decrease request change by facilitating, optimizing, and forming abilities (Anand and Kodali, 2008). These tools are Kaizen, Value Stream Mapping (VSM), JIT, Kanban, 5S, Single Minute Exchange of Dies (SMED), Visual Management Systems, Total Productivity Maintenance (TPM), Automotion, Stardization Work, Takt Time Analysis, Cellular Production, Jidoka, Poke-Yoke, Andon, Heijunka, Lean Six Sigma, Hoshin Kanri and Kamishibai as follows.

1.9.1. Kaizen

The word 'Kai' means for changing and the word 'Zen' means for better. Therefore, Kaizen involves constantly changing in order to better include each employee in the firm (Singh and Singh, 2009). Chandrasekaran et al. (2008) used the Kaizen tool to find a solution to the problem of part incompatibility in an auto firm's assembly line. Kaizen uses the tool to collect data, analyze root causes, discover and select good solutions of various possible solutions, and eliminate problems step by step through implementation and appropriate documentation. It decreases waste due to the rework of products after the application of Kaizen, decreases the shortage of quality, and provides high-spend savings (Gupta and Jain, 2013). The Kaizen tool, if applied correctly, is a scientific and systematical approach that not just reduces redundant jobs, however, also determines and reduces waste for people in an operation (Knechtges and Decker, 2014). Kaizen means constant healing. Kaizen is a lean production tool that decreases and determines activities that do not add value, provides novelty and creativeness, influences changing in a short time, and raises efficiency (Ortiz, 2006). The use of the Kaizen tool by firms will provide them with higher quality and novelty products and positive success, and they will have started a constant healing way (Prajapati and Deshpande, 2015).

Kaizen tool is the notion of constant healing, which supposes continuous research to opinions to develop whole spaces of the firm. It wants the involvement of the whole of the firm's workers, operatives, from the high grade of administration (Sultanov and Özçakar, 2010; Hamrol et al., 2015). In the Kaizen tool, the purpose is achieved with the idea that waste is unused to human ability and mind (Kılıç and Ayvaz, 2016). Employee's performance is effective in the success of a job. So, the Kaizen tool focuses first on employee and performance, and therefore it bases an effective employee motivation (Kucerova et al., 2015). With the Kaizen tool, developments may be slow, but the results will grow over time and will be more robust. Kaizen derives its success from its employees and their success, not from machinery and equipment (Ortiz, 2006). It ensures uncovers the technic abilities and inventive information of the whole of the employees included (Thurston and Ulmer, 2016).

The Kaizen tool promotes constant healing and eases action into reducing pollution and material waste (Miller et al., 2010; Vinodh et al., 2011; Pampanelli et al., 2014). Kaizen tool utilizes to eliminate the bottlenecks due to the decrease in cycle time, raising fruitfulness, and removing lean waste (Arunagiri and Gnanavelbabu, 2016). Kaizen indicates healing in the production, concentrated at clients, healing of whole operations in the value chain of job actions with simultaneous minimization of cost (Kucerova et al., 2015) and it eliminates waste and replaces them with actions that create permanently added value (Rewers et al., 2016).

1.9.2. Value Stream Mapping (VSM)

VSM is a world famous graphic tool. Analyzing and illuminating work stream is a tool that assists determine and find VA and NVA activities for a product (Gupta and Jain, 2013; Bulut and Altunay, 2016). Rother and Shook (1999) presented VSM where baseline analysis of a product’s value stream is performed. After the again-design, it focuses on reducing delivery time, reducing waste, improving material stream, and improving the coming status of a product’s value stream. Compared to other tools, VSM is the tool in which a map is necessary to indicate information and material flow. Pattanaik and Sharma (2009) specified that the operations require analysis for eliminating the NVA activities that another waste such as waiting time, tail waiting time, movement time. VSM is the initial step in implementing lean and it ensures a map of the existing status of the firm. It is the map that indicates the VA and NVA activities of the production process from the raw-material stage to transfer to clients. This map is utilized to determine causes for wastes and to determine what lean tools must become utilized to decrease these wastes. After implementing required lean production tools, other map is improved that indicate the coming status of the firm (Abdulmalek and Rajgopal, 2007). Ringen et al. (2014) explained that this visual tool assist determination of the secret waste and resources of waste.

VSM is a tool that utilizes signs identified qua the lean language to describe and develop the material, information, and inventory stream (Rother and Shook, 2009; Rewers et al., 2016). The map indicates whole the duties assumed in a process, from the buying of raw-materials and concluding with the transfer of ended products to the client (Rewers et al., 2016). The purpose of VSM is to determine VA and NVA activities and Value Stream Maps must mirror what in fact becomes rather than what is supposed to become so that chances for healing would become determined (Hines and Taylor, 2000). Also, it utilizes to healing and process analysis with determining and removing time wasted on NVA activities (Capital, 2004). VSM become utilized as a waste determination tool to describe lean healing chances linked to eliminating NVA operations. The higher NVA activities in the value stream the lesser lean a system is (Kayanda, 2017). In existing situations, processes are getting better by making them repeated in certain periods with constant healing in order to reduce and eliminate waste (Adalı et al., 2017). What becomes a product at every step in its production is defined in the value stream, from design the product to order raw-material and lastly deliver the prepared product (Tran, 2016).

VSM is beneficial in defining peripheral effects in the production operations and developing peripheral performance thanks to decreasing junk material and faulty (Brown et al., 2014; Chiarini, 2014; Esfandyari et al., 2015). Research studies have shown that firms applying VSM will reduce delivery and production time, make production smoother, reduce waste, and develop product quality (Goriwondo et al., 2011; Kanyanya, 2013). VSM rises elasticity, decreases operational costs, and fulfills client’s requests. Material and information stream is provided, showing error ratios and installation time (Prajapati and Deshpande, 2015).

1.9.3. Just in Time (JIT)

JIT is a lean production tool for the application of the incidents required to manufacture a final product and make an accomplished plan (Gupta and Jain, 2013). Karlsson and Ahlstrom (1996) have specified that every incident and operation must become handled in the correct shape, in the correct requirement to generate products, and by the correct time. The main purpose of JIT is to provide each process one piece at a time, when there is a need for that piece entirely, and that is the basis of JIT. Decreasing party dimensions, buffer dimensions, and order delivery times are shown qua the significant elements of JIT with these scholars. JIT involves generating and ensure just whatever is required and the amount that is required at the correct time and while it is required (Koskela, 1992). The JIT tool is the key point of the TPS. The purpose of TPS is to reduce costs. For this reason, the JIT tool is said to produce only the units needed, in the time and amount needed (Özkan et al., 2015). JIT is a pop inventory model and lean production tool utilized in the supply chain, producing the correct quantity of product at the correct time, meeting the quality needs (Wang and Ye, 2018). It occurs with the correct space, amount, position, time, cost and order in the system and by using the appropriate and correct materials (Halim et al., 2012). JIT tool identifies and solves issues in the system. It aims to eliminate costs and is commonly utilized (Prajapati and Deshpande, 2015). JIT is close connected with lean production as it is an administration opinion that attempts to remove resources of production waste by generating the correct piece in the correct space at the correct timing (Dutta and Banerjee, 2014). JIT provides advantages become specified qua a raise in fruitfulness, healing of the quality operations, decrease in waste and reprocessing, decrease of total production cost, and which conclusions in a raise in production quality (Alcaraz et al., 2014). Investigation works specify that by utilizing JIT, the firm decreases the production cost, changing time, inventory, probable waste and setup time (Womack and Jones, 2003; Kanyanya, 2013). Also, it ensures developed quality, raised response, decreased cost, reduced inventory grades, developed fruitfulness, reduced delivery time, and decreased fault time (Yasin and Wafa, 1996; Imai and Kaizen, 1997; Abdallah and Matsui, 2007).

JIT is a production planning notion that includes whole raw-materials, processing, and completed products to become present exactly while required. So, it is waited to decrease the grades of inventory, quality, and production grades (Kannan and Tan, 2005). JIT tool is an important component in the improvement of lean production in a lot of firms (Abdallah and Phan, 2007; Shehadeh et al., 2016). It indicates an endeavor, to reduce waste during all production operations, from the buy of materials and semi-finished products to the deployment of completed products. Production utilizing the tools of JIT involves generating needed kinds of products in the needed amounts, at the needed time, when providing 100 percent quality, therefore, that it is probable to eliminate the causes for the inventory should become protected (Mlkva et al., 2012). A production system concentrating on the removal of waste (non-value-adding actions) in the production process with the on-time, a series of processes

(Gass and Fu, 2013).

1.9.4. Kanban

The Kanban tool is a compatible knowledge system that controls the production of products among firms and in production operations, at the needed time and in the needed amount (Hidayati and Shalihin, 2020). Kanban concept is a significant lean production tool that assistance the following of material, operations, and job stations, making it simpler for workers to define the knowledge and it decreases cycle time (Lin et al., 2013). Kanban is a knowledge system utilized to check the amount of pieces to become generated in each operation. The most widespread kinds of Kanban tools are divided into two. These are the draw back Kanban indicating the amount that the next process must withdraw from the previous process, and the Kanban production from the previous process, specifying the amount to become generated (Monden, 1998). The Kanban tool is a Japanese production check tool that does not depend on a production program and takes control of the situations that occur straight in production (Rewers et al., 2016).

Kanban is used in Toyota pull system. Kanban is a tool that realizes JIT production and enables pulling between production lines. Kanban is defined as the information flow that enables the operation of the pull system (Özçelik and Cinoğlu, 2013). The Kanban tool, a supplier, should give them to the production line just while needed, at the production site, so that the pieces do not enter the warehouse. There can be a major issue in production lines, assembly processes, and often the pushing system is used here. Therefore, the Kanban means, which forms the pull system instead of the pushing system, has been created. For a good product stream, Kanban is important (Gupta and Jain, 2013).

The word Kanban comes from Japan. The word ‘Kan’ means card and the word ‘Ban’ means signal (Gross, 2005). The Kanban tool is defined as a plastic card that shows detailed information of a product, its stages of assembly and production, and the completion of the product. It is a multi-stage production scheduling method that controls stocks (Kumar and Panneerselvam, 2007). Kanban also is visual recording (Hidayati and Shalihin, 2020). Kanban is a draw-based system that uses visual signs, like color cod cards, to send signals to upstream job stations if entries are needed downstream of the job station. So, Kanban is a means of communication based on the pull method. Kanban can become a card or electronic screen as a visual signal (Capital, 2004). The Kanban tool is a card that states the quantity and type of product drawn. This card is sent to the previous process as a production order. Thus, it takes the material from the previous process in the amount and time required by the next process. The previous process produces as much as the next process takes (Özçelik and Cinoğlu, 2013). These cards contain different information such as the product code, name, and where it is stored. The question of when more material is needed is answered with signal cards and automatic renewal takes place. The stream of products and materials with both the client, the supplier, and the facility is ensured (Öksüz, 2017). Material is not moved and generated unless Kanban is a signal from the client. It is a lean tool with minimal inventory purpose at any given time (Rahman et al., 2013). In addition, its other purpose is to ensure that the raw-material and material needed are at the desired place and on time and to reduce the stock levels in and out of production (Kılıç and Ayvaz, 2016).

Kanban represents value in wasting and ensuring constant healing (Sultanov and Özçakar, 2010). The Kanban tool is successfully applied to Japanese firms. Because it enables elastic job stations to improve, does not overproduction, reduces logistics costs and waiting time, saves costs, decreases junk and waste, causes inventory stock grades to decrease (Rahman et al., 2013). In addition, Kanban’s other benefits include preventing faulty production, replace shipping, and order receipts, keeping warehouses under control, preventing semi-finished products from accumulating from previous processes, and saving space (Kılıç and Ayvaz, 2016).

1.9.5. 5S

5S is a process improvement tool used to clean workplaces, reduce waste, and improve the efficiency of labor. Optimizes the structure of a process and for the implementation of other lean production tools, the 5S tool is one of the first tools to be implemented (Al-Aomar, 2011). 5S is a tool linked with productive job place set-up and regulated job functions (Abdulmalek and Rajgopal, 2007; Aka et al., 2019). The 5S is a lean production tool that provides a streamlined and clean job place floor, as well as raising efficiency with a good cleaning (Prajapati and Deshpande, 2015). The 5S is to uncover issues and solve them; and consequently, the waste is eliminated from the operations (Thurston and Ulmer, 2016). The basis goal of the 5S applications is to ensure a secure, orderly, and productive job station, finishing in the decrease of waste and development of the performances of employees and in operations. Also, 5S is not only to arrange and tag products and devices and to form a bright atmosphere. It is a promoting tool to lean administration for providing the regular stream of people and materials (Shivanand, 2006). 5S tools do not want big monetary fund and it is the initial stage in increasing the workers a feeling of having in connection to the job place (Rewers et al., 2016). The 5S tools saw that it points to the decrease of wastes in waiting, redundant move, inventory wastes in production operations (Skinner, 2003).

By applying 5S tools, in addition to providing andantages such as raised security grades, cleanuping the working area, increased efficiency, and protective care (Gupta and Jain, 2013). It can also be said of advantages such as an efficient and fresh job atmosphere, developing the quality of products and services, low cost, keeping productivity and effectiveness in operations high, decreasing waste the need for the lesser area for warehouse, decreased generation and installation time and decreased laborforce time (Veres et al., 2018). Developed by the expert Hiroyuki Hirano, 5S consists of the initials of the words Seiri, Seiton, Seiso, Seiketsu, and Shitsuke in Japanese (Çanakçıoğlu, 2019). These are as follows.

Seiri (Sort): Seiri or Sort involves saving the workplace from unnecessary parts. The number of parts required for those working in a business area is very few and if these parts are not very important they are ignored. If the classification is not done, the necessary parts will be invisible among other parts and the worker will start with activities that do not add value to the work and are wasted (Ortiz, 2006). With the Seiri, insulate and avoid whole material that is not beneficial (Prajapati and Deshpande, 2015). The first stage in Seiri is provided firstly with reduced inventory and good utilize of the work area. Whole redundant parts must become identified by a red mark and located in a decided space (Antosz et al., 2015). It is allocating the materials required pieces of materials that are not needed, next throw redundant pieces from the job place and warehouse of products (Hidayati and Shalihin, 2020). It determines what is necessary and what is not, and refers to the simple find of constantly required items by keeping them close by (Capital, 2004).

Seiton (Straighten): Seiton or Straighten includes the stage of the arrangement to find and use the materials and equipment that are constantly needed in a working environment in a short time and easily (Jassim, 2018; Çanakçıoğlu, 2019). Seiton is a systematic process and it is the arrangement, determination, and choosing an appropriate area for whole tools in the job station. It means to decrease the redundant stream of workers while the personnel is looking for a tool and to remove the mistakes that occur in the quality of the products that occur due to mistakes, by putting the correct mark (Antosz et al., 2015). It arranges necessary items for simple accession. The purpose is to reduce the quantity of action needed for employees to perform their works. For instance, a toolbox would become utilized by an operative or caring personnel who should utilize different tools. In the toolbox, each tool is located in constant locations that are easy to find by employees. This layout ensures that employees are directly notified of any deficient tools (Capital, 2004). One of Seiton's important rules is to put something in the right perspective. So, each piece must have its own place in the field of business. The pieces are marked with a colored tape. First, the color type is determined and then the color is chosen for each piece to ensure the standards (Sultanov and Özçakar, 2010).

Seiso (Shine): After getting rid of unnecessary items, it is time to clean and keep the workplace clean. The workplace should be kept clean and given an image like an exhibition hall. Cleaning is done not only for the image but also to prevent possible damage. Tools and equipment are also kept clean and well-maintained, ensuring their long life, reliability, and proper use (Sultanov and Özçakar, 2010). Seiso has cleanup and care of the job place and determines the standard of suitable clean. Seiso stage's purpose to determine and remove the reasons for pollution, and maintenance of machines (Antosz et al., 2015). Seiso (other named brightness or sweep) is a job space that keeps it clear and orderly (Hidayati and Shalihin, 2020). Seiso is making the job place do the place clear of dirties and waste (Jassim, 2018). In some sectors, airborne powder reasons color pollution and bad product face. Therefore, firms utilize a higher luminosity to be aware of the dust by painting their job places in light colors (Capital, 2004). It is concerning be workspaces regularly fresh. For example, the machine productivity and product quality of a dirty space reduces, and care costs raise. Also, staff's, living security reduces and actualize staff's energy decline (Çakırkaya and Acar, 2016).

Seiketsu (Systemize): Seiketsu or Systemize is the stage of setting standard procedures and rules for the improvement of previous developments after the organization and cleaning of a workspace (Çanakçıoğlu, 2019). Cleaning and organization needs must be clearly stated to the stations. For this, standards must be written to ensure and improve the implementation of the 5S tool. The operative should follow the arrangements such as the layout of parts and tools as needed to increase the productivity of the workers (Sultanov and Özçakar, 2010). It identifies the procedures to the initial three steps of 5S. This step essentially describes the duties of staff and forms directions, sustaining the application of the prior steps (Antosz et al., 2015). It does it a regular application of the three S (Seiri, Seiton, and Seiso) (Capital, 2004; Antosz et al., 2015; Hidayati and Shalihin, 2020).

Shitsuke (Sustain/discipline/self-discipline): After a certain time, people return to their old habits. Therefore, the previously applied 4S (Seiri, Seiton, Seiso, and Seiketsu) should be continued and developed. For example, there is a small competition between workers on the job site and the assembly line (Sultanov and Özçakar, 2010). This tool allows workers to quickly adapt to changes in their habits and fit with previously imposed standards. It is a hard and length process. Because it forces firms to change administration and employees (Antosz et al., 2015). Shitsuke is done that discipline be a routine by watching the directions that have been appointed (Hidayati and Shalihin, 2020). Expressing the importance of employee loyalty and strengthening good work habits in order to have a regular, safe, and proper job, and to continue the gains from the implementation of the 5S tool, efforts must be made. So if there is no discipline, the sustainability elements will result in the failure of the 5S tool, and everything goes back to the previous mess (Agrahari et al., 2015). It is necessary to introduce, correspond, and educate 5S to provide that it is a piece of the corporate culture of the firm (Capital, 2004) and whole workers are included in this process and it is necessary to provide that continuous cleaning is protected (Prajapati and Deshpande, 2015).

1.9.6. Single Minute Exchange of Dies (SMED)

Single Minute Exchange of Dies (SMED) is the lean production tool to eliminate waste and improve efficiency by reducing setup times. The SMED tool is an important tool in lean production due to the short setup time of firms in the transition from mass production to lean production (Dillon and Shingo, 1985). It is known as ‘Single Minute Exchange of Dies’ developed as a result of 18 years of study and analysis on preparation times and Shigeo Shingo's (Rewers et al., 2016; Tanık, 2010; Waller, 2003). This method is called this name because the aim is to reduce the preparation time to less than a minute (Waller, 2003; Rewers et al., 2016). However, the expression 'one minute' in SMED, which is one of the lean production tools used to reduce the waste in production, is not used to mean that all changes take only one minute. This expression is used to mean 'single digit minute', that is, it takes less than 10 minutes (Kumar and Bajaj, 2015). SMED is a tool applicable to each machine in each facility. The most important feature of Shingo's system is to separate the internal adjustment operations that can only be carried out when the machine is turned off, from the external adjustment operations that can be performed while the machine is running. Shingo's system includes the theory and practical applications needed to reduce the setting processes to under 10 minutes (Tanık, 2010).

SMED is a tool associated with elastic production systems and small batch production (Tanık, 2010). The lean system is a faster and more productive process for working the SMED tool from one product's process to another and also decreases waste. The fine-intended SMED tool makes good utilize of sources by looking at the inventory grade and time of the particular product (Kayanda, 2017). SMED aims to make transition times of a range of operative methods, generation equipment, and operations in lesser than 10 minutes (Burton and Boeder, 2003). SMED is a systematical process to reduce downtime (Kucerova et al., 2015).

The practice of the SMED tool has provided success and competition on behalf of production firms. In addition, SMED enables the reduction of batch dimension, short installation time, reduction in overall programming and planning, removal of waste, use high productive of sources, higher-quality products that satisfy the needs of clients (Prajapati and Deshpande, 2015). SMED, if implemented, provides the following benefits. Preparation times are reduced, the work of the machines increases, the final product stock, and inter-process stocks are reduced because of the small batch production, it responds quickly to fluctuations in varied products in demand (Shingo and Dillon, 1989). It decreases delivery time, higher elastic response to the client request, decrease inventory grades due to lesser lot dimensions (Burton and Boeder, 2003).

1.9.7. Visual Management Systems

Visual Management Systems ensure that employees are informed regarding production procedures and another knowledge so that they can do their jobs efficiently. Big visual displays are a higher efficient tool than inscribed papers to employees and must therefore become utilized frequently. If there is to be an adaptation to a process, visual presentation enables employees to perform their actions in an accurate series of incidents. The first visual tool is visual displays. These are graphics, measurements, and operation documentation for production employees. The second is visual checks. These are for employees to check their work and send signals. It also includes production situation knowledge and quality monitoring knowledge. For instance, a color-coded panel can be used for heat and velocity adjusting check levels so an operative can rapidly describe the operations. Kanban cards are also other samples of visual checks. The third is the visual process index. These inform the right production operations and material stream. For instance, this involves the utilize of colored ground spaces to non-faulty stock and junk and index for accurate material stream on the facility fold (Capital, 2004).

1.9.8. Total Productive Maintenance (TPM)

TPM is a tool that requires the participation of all employees in production activities, and wants the operatives to maximize the efficiency of the machine and equipment they work on. TPM has been developed by the Japan Institute of Plant Maintenance (JIPM), which applies the concept of total efficient maintenance to equipment to achieve zero failure and minimum production losses (Görener and Yenen, 2007). In TPM, machine operatives are responsible for daily maintenance, periodic inspection, and preventive maintenance of the machines they are responsible for. TPM is the adaptation of the Total Quality Management (TQM) philosophy to the maintenance function. In particular, leaving the thought of ‘the producer produces, the maintenance man makes maintenance’, the producer is held responsible for the maintenance and repair of the machines up to a certain limit (Köksal, 2007). TPM gives employees the responsibility to proactively describe, watch, and fix the reasons for redundant downtime of machines. This is the responsibility of the machine operatives, and as care issues are lesser, machine downtime is decreased. In this case, the operative should inform the care crew regarding the status of the machines often.

Therefore, possible technic issues are anticipated and stopped. Care crew is liable for high-value-adding care actions like equipment healing, revisions and healings, troubleshooting, and education (Capital, 2004). TPM is an administration tool that becomes concerted to suddenly decrease machine failures during the progression of the job (Feld, 2000). It develops equipment trustworthiness, which raises equipment productivity round the living of the equipment (Swamidass, 2000), and increases productivity ratios by removing redundant waiting in the operations (Chan, 2005).

TPM is utilized by a firm to remove waste from technologic machines. This tool integrates whole workers. Because production continuity must be ensured (Michlowicz and Smolińska, 2014). The principal purpose of this tool is to raise the productivity and fruitfulness of machinery and equipment in an evident decrease in the number of failures, decreasing the time renewing and setting machines and idle and brief downtimes (this reasoned often unavailable worker, waiting for tools, material, knowledge), decreasing failure in quality of the product, reduced time wasted on while the starting of production (Rewers et al., 2016).

TPM aims to reduce conflicts and incompatibilities. It concentrates on the participation of the whole worker. This situation is separated for the worker into who works in the machines and who fixes machines (Košturiak and Frolík, 2006). The TPM optimizes the efficiency of production equipment, and team-based efficient care includes each grade in the business, from workers to managers. The purpose of TPM is profitable efficient care. TPM wants not just to stop failures, and errors, however, to become economic and fruitful at all times (Dutta and Banerjee, 2014).

1.9.9. Automation

Automation involves the autonomous check of amount and quality. The first opinion was that each employee is individually liable for the quality of the piece and the product they generate. Later, generally, the examination is made automatically (Swamidass, 2000). Lean production consists of automation, robots, and electronic sensor systems. As a general principle, managers in lean production only use automation when it is better than humans. People are smart and very flexible in their job assignments, and Automation robots are efficient and accurate in their job assignments. Lean production workers are very flexible and are used in many ways. For this reason, automation is preferred in places where things are busy, boring, and monotonous. Computer-controlled electronic sensors are used instead of humans, especially in situations that require clarity and accuracy. But going to automation to do automation is wasteful because automation is very expensive and hinders the flexibility of operations (Schniederjans, 1993).

1.9.10. Standardization Work

Another lean production tool that ensures continuous improvement and eliminates errors is the preparation of documentation of existing processes. In the documentation, there are detailed and individual procedures for each job. These procedures need to be followed consistently, so the issues in the work series are always reviewed. These procedures change depending on the changes in business conditions. In this case, waste is prevented and it is ensured that training of new personnel is made easier and mistakes are reduced. Therefore, standardized operation increases quality, safety, and productivity (Emiliani, 2008). Standardization work is a tool utilized in lean production for the healing of jobs and develops the sustainability of generation operations (Antosz et al., 2015). Standardization involves uniform processes and duties from whole operatives. Standardization work is the top tool of the process. This allows the exercise of all steps in the same way, in the same order and time, at a fixed cost. Standardization accepts constant improvement of a novel, good standard, so as to fit the frequently change client wants (Rewers et al., 2016).

Standardization work (also named standardized work and standard process) means that production operations and procedures are very clear explained and detailed to remove changes and false predictions in the shape the work is made. Its purpose is that production processes must become run identical every time, outside of when the production operations are deliberately changed. If production instruction is not higher standardized, the employee has dissimilar opinions about what the right working instruction is and can simply do false predictions. The higher grade of operations standardization does it easy to the firm to continuously expand its capacity (Capital, 2004). A significant basis for waste removal is the standardization of employees activities standardized work actually provides that every work is regulated and is applied in a very operative style. A tool that is utilized to standardize work is named Takt Time is. Takt (German for beat or rhythm) time relates to what frequent a piece must become generated in a product family connected to the real client requests (Dutta and Banerjee, 2014).

1.9.11. Takt Time Analysis

Takt time means the speed of the products passing from the production line. It is obtained by adapting the production ratio to the product request ratio (Prajapati and Deshpande, 2015). It is an important tool of lean tools because of its practice and information. Takt time is calculated by dividing the available time by the required request ratio. The timely delivery of products for the client's needs is done with this tool. Thus, wastes due to overproduction are prevented (Page, 2004). But the constraint of the analysis is the hassle met when implemented where there are equipment and machines used for the production of different products (Prajapati and Deshpande, 2015).

1.9.12. Cellular Production

Cellular Production is a tool that systematizes the whole operations, all the necessary equipment, operatives, and machines, in a set and cell for concerned products and a specific product (Aka et al., 2019). Cellular Production is a notion that raises the mixture of products including the least shrinkage feasible. A cell is consists of equipment and job stations and is coordinated, to continue a sleek stream of sources and ingredients along the operations (Dutta and Banerjee, 2014). Cellular Production is described as a lean production tool in which machines and equipment are agreeably prepared to develop the constant move of materials and tools along the production operations without slowing down or wasting time (Prajapati and Deshpande, 2015). It is production system that associated the group of operations, persons, and machines to generate a particular value of products due to production features by parallel sorting. Low cost, decreased ways of handling, the sleek stream of materials, decreased grades of inventory and process stage, and decreasing answer time are the top significant pieces of cellular production (Jassim, 2018). The principal advantage of cellular production is that it helps enterprises to decrease the general cost because an individualistic employee would watch and administrate a sequence of machines and equipment in the production canal (Prajapati and Deshpande, 2015).

1.9.13. Jidoka

Jidoka includes the phenomenon of automation. It is not limited to stalls only. Emerges as a tool that includes manual processes and operations. Jidoka was first introduced by Sakichi Toyoda in the early 20th century, in the textile industry, when the thread broke, when he invented a standing loom (Zeybek, 2013). Waste rates are one of the important issues discussed by firms. A waste rate of 1 to 3 percent is shown by many employees as a good level. However, wastage always means lost money for firms. Jidoka tool, a Japanese technique, targeted the waste rates as zero (Kaymkaçı, 2012).

The Jidoka tool is used to find and prevent simple errors in employee’s work. It also shows that the operatives have the ability to stop the machine and the production line in the occurrence of a problem and malfunction during production. Therefore, operatives ensure efficient production by detecting abnormal situations that occur and stopping the processes. Accordingly, the increase in production errors is prevented and abnormal situations are controlled. The workers who stop the machines do the necessary corrections and develop their own skills for the next time (Womack et al., 1990; Sugimori et al., 1977). Issues might become linked to the quality of products and lags the production operations because of a shortage of material, vehicle knowledge. Tools that provide the application of the tools Jidoka are Poka-Yoke and Andon (Womack et al., 1990).

1.9.14. Poka-Yoke

Poka-Yoke is also known as proof of the error (Mears, 1995). This tool thinks that if there are places with human intervention and hands, there is something wrong here. It was previously called Baka-Yoke (floor-proof) and was developed by this name. But later the name was changed to Poka-Yoke because the Baka-Yoke means managers viewed the workers as stupid (Levinson and Rerick, 2002; Pekin and Çil, 2015). The Poka-Yoke tool is important for firms to be lean towards being lean. This tool increases profitability avoids overtime, delays, and faulty goods production. Since reducing waste is one of the first rules of being lean, it is an important tool for lean businesses. When the production of error and faulty products decreases, these wastes are disposed of (Allen et al., 2001). The five principles of Poka-Yoke developed by Nakajo and Kume are as follows. The first principle is the elimination principle. This reduces the chance of error. For example, processes, tasks are designed so that they are not very important. The second principle is the replacement principle. This is a more reliable process for employees. For example, a robot be used. The third principle is the facilitation principle. This simplifies the way the work is done. For example, color-coded parts are used. The fourth principle is to find errors before forward process. For example, if the wrong key is pressed, computer software developed and this inform. The fifth principle is reducing errors and false. For example, using fuses due to the overload cycle (Juran and Godfrey, 1999). Poka-Yoke also provides feedback. When a worker presses the button with any problem, others get feedback by touching, hearing his voice, and seeing (Sultanov and Özçakar, 2010).

The word ‘Poka’ means distraction, carelessness, and unwanted error. The word ‘Yoke’ is derived from the word ‘Yokeru’, which means to eliminate. For this reason, Poka-Yoke is defined as an electronic and mechanical mechanism that eliminates and prevents human error. Its purpose is to establish a system that continuously improves the process, prevents the repetition of errors in the processes and the production of faulty products (Pekin and Çil, 2015). Also, other purposes of Poka-Yoke to realize zero-defect production without the need for a control element by developing preventive tools and strategies against mistakes caused by human, carelessness, and forgetfulness (Zerenler and Karaboğa, 2014). It removes product errors with people’s mistakes stopping, fixing, and pushing interest (Dudek-Burlikowska and Szewieczek, 2009).

Poka-Yoke is a tool utilized to error-proof an operation to stop the operative from forming an error product. Error proofing assists remove the chance of combining anything in unit false (Thurston and Ulmer, 2016). Poka-Yoke is applied so that faulty material does not go into the production operations (Capital, 2004). Poka-Yoke is a technology of utilizing tools and methods to stop errors and faults in the process of equipment and operations (Burton and Boeder, 2003). In Poka-Yoke is probable to get the decreased time needed for training workers, removing a lot of quality check process, decreasing the quantity of errors, and 100 percent check of the operations (Fisher, 1999).

1.9.15. Andon

As a result of advances in technology, the ability to stop machines has also been used. Andon is a visual management tool that draws attention to processes in the production area, such as which machines are stopping and running, operative delays, quality defects and lack of material, and signals when an abnormal situation occurs (Marchwinski et al., 2011). In lean production, a problem in a process stops another process, and flags or lights, usually accompanied by music, sound an alarm when there is a quality problem, and warn for help (Liker, 2004). In the Andon system, if the green light is on, it indicates that everything is going well, if the yellow light is on, it indicates that there is a problem, and if the red light is on, it indicates that the line has stopped (Russel and Taylor, 1998). Andon is also known as hazard light. In a process, when there is any problem, the light is turned on automatically or manually, and attention is concentrated. Solutions to these problems are found by the auditors. If there is a problem with the quality, machine, and production schedule in lean production, the operatives should push the button, and they pull the Andon cable (Womack et al., 1990; Suzaki, 1993).

1.9.16. Heijunka

Heijunka is recognized as the level of production balancing and job loading. It is applied to balance the product variety schedule and production to be produced. This tool is concerned with the pull system, steady flow, and low stock levels (Chase et al., 2004; Sayer and Williams, 2007). It is a vehicle where each of the products is produced in a balanced way of the produced products order and the production is made according to client demand. An important feature of Heijunka is that demand change and unaccounted finished and in-process stocks are not encountered, and it is easily adapted. More than one product and model are mounted on the same line. Thus, the number of lines and factory areas is reduced (Kılıç and Ayvaz, 2016). The client’s needs vary. Although there are many loads for production one day, another day, if the client does not need it, the production line remains idle. This does not affect not only firms but also suppliers. It pushes suppliers to hold stocks due to uncertainty and affects them as well. A firm working on order creates longer waiting times for the client (Monden, 1993). It is impossible to be such a lean process. Therefore, by collecting all orders and ensuring a balanced state of production planning, the client is offered short completion times (Sultanov and Özçakar, 2010).

Heijunka's purpose is to eliminate leaps in production. Heijunka is known as the tool of sorting products to raise efficiency and elasticity by removing waste and reducing variation in freight job stations (Hüttmeir et al., 2009). This tool occurs of determining the order of operation and the stream of the operations so that the valid request is fulfilled from the warehouse or supermarket, and does not reason abrupt changing in the production program. The production program must become in the provided term of time fixed. Time is mostly linked to the season of products. The purpose is to provide that the products are manufactured in batches of several parts in a specific order. So, determining a production level is a tool of providing validity for clients, with repetition and the same stream of products and consumables in the store. The repetition product stream from production lends to a burden balance job stations (Rewers et al., 2016).

1.9.17. Lean Six Sigma

Six Sigma is a disciplined and datum-oriented tool that improves job and production operations, increases the profitability and product quality of firms. These operations include production, products and services, and job applications (Dutta and Banerjee, 2014). Six Sigma is under the Japanese concept and has an important place in lean production. Because the number of failures and unsuitability per lot is administered to a low level of almost zero. Thus, there is not reprocessing and rework, because these are by wasting a lean philosophy (Womack and Jones, 1996). It is suggested to connect Lean Six Sigma quality administration philosophy by Six Sigma with the lean method. The Six Sigma tool is an efficient method to improve the quality of operations. Lean Six Sigma practices are connected to the decrease in production prices. Firms try to decrease the production prices of the products needed by their clients while protecting the wanted features. Lean Six Sigma implementation assist to raise gains (Kucerova et al., 2015). Six Sigma is a tool that removes errors for products (Jayaram, 2016). Albliwi et al. (2015) provided the first ten advantages obtained from the application of Lean Six Sigma as follows: **(1)** raised gains and monetary savings; **(2)** decreased cost; **(3)** raised client pleasure; **(4)** developed key performance criteria; **(5)** decreased cycle time; **(6)** decreased inventory; **(7)** decreased errors; **(8)** decrease in machine failure time; **(9)** raised generation capability; and **(10)** developed quality. George (2002) describes Lean Six Sigma as: A method that increases stockholder value by reaching the quick ratio of healing in client pleasure, cost, quality, operation velocity, and investment fund. Lean and Six Sigma promotes price of confusion decrease (George, 2003). This combination of two methods indicates the means of making made quicker, good, more inexpensive, more harmless, and greener (Pacheco et al., 2015). Antony et al. (2003) limited the view that the healing abilities of Lean and Six Sigma reach the optimum level and height of individualistic opinions and that integration will accelerate the processes of the firm, work at low costs, and provide the ability to respond to the client with their effort. Thanks to its "six" sigma feature, it provides excellence and more elasticity along the job.

Six Sigma utilizes the standard way to Define, Measure, Analyze, Improve, and Control (DMAIC) cycle (Jayaram, 2016). DMAIC is utilized for process healing (Sirshar et al., 2019). In DMAIC stages are; in define stage; clients are described in the define stage. The job issues by the purposes of the firm and the clients are described (Jayaram, 2016). The client wants are turned in particular needs and the techniques of collecting client knowledge are described (Selvi and Majumdar. 2014). In measure stage; it evaluates the performance of an operation that becomes utilized for healing. Usually, the team determines which element must become measure and how it must become measure. Datum from the measurement stage compares by datum on the finish of the project to evaluate if the healing is efficient and requires more healing. In analyze stage; describes the parent reasons for errors at an elaborate grade. Operations entries and throughputs are analyzed round with the datum to describe which is the important element is the basis reason for the error. In improve stage; resolutions to eliminate the errors are described. With determine a series of factors in the operation, the operation would become heal to a big degree. In control stage; with providing the healing done in the operation, the check is applied. Different tools are utilized to watch the factor that does not pass their described levels (Jayaram, 2016).

Tools to healing centered on Lean and Six Sigma in last time have demonstrated efficiency in accomplished firms. The practice of these notions is especially beneficial where there is powerful client focusing, quality, time, cost, and performance operations (Kucerova et al., 2015).

1.9.18. Hoshin Kanri

The Hoshin Kanri tool enables firm administration to focus on the improvement skill for the entire performance of the firm by developing policies and yearly administration planning connected to its fundamental concept (Witcher and Butterworth, 2001). Hoshin Kanri has a diversity of practices in the firm, from strategic plan technics to the quality administration systems to the operational systems, to provide and grow regularly gain to administrate complicated projects. For example, novel products are manufactured in the firm in answer to client requests. The activities of this tool are realized as follows: to describe the mission and vision in with a general strategy; determining strategic purposes (3 and 5 years); describing yearly purposes; application of the purposes; checking purposes; yearly assessment of the achieve of the purposes (Rewers et al., 2016).

1.9.19. Kamishibai

The Kamishibai tool is a series of easy audits designated to check a business, utilize lean production methods, and instruct the controlling person to discover potential healings in operations. The important component of this tool is Kamishibai placed straight in the production route. A layout plan is provided for the inspectors in order to carry out documentation and controls. With this tool, the inspector becomes whichever person laboring in the firm. For instance, employees, guards, generation personnel, accountancy, and center bureaus, can become inspectors. This is probable through a much easy designing of the sheet control. The sheet includes the best extensive check-list of areas to control in the shape of pictures throughout by the position of the place on the map order (Niederstadt, 2014).

The Lean Production System is explained in detail in Chapter 1. The definition and principles of the lean concept, the historical development of the lean production system, purposes, core components, principles, benefits, and tools are explained. Waste Management will be explained in detailed in the next section.

CHAPTER 2
WASTE MANAGEMENT

The center of the lean idea is to remove all waste, so, whole actions with no additional value. Waste might become dimensioned together with time, inventory and unneeded costs. VA activities are actions that provide the effective transfer of the ultimate product to the client. Inventory and supply chain should stream in the chain. Any actions that pauses stream and touching inventory should form value. The lean idea might become readily implemented in a comparatively steady and for this reason anticipated situations where client's wants (request) are alike (Kimani, 2013).

Allen (1994) described the five steps of a waste hierarchy. The first step, disposal generally landfill either firing is the lowest appealing waste management selection. The second step is the return of value either power of waste elements. This involves composting, element recycling, and the return of energy from wastes. The third step, reuse includes setting object back in utilize they make not access the waste flow. Reduction opinion is the major primacy to sustainable waste management: The decrease either minimum of waste in the resource. The last purpose is the whole removal from waste with radical operations exchanges. This hierarchy of activities is generally named '3R' (Reuse, Recovery and Reduction). Azimi Jibril et al. (2012) say that the 3R hierarchy is strategic touch on strict waste management. 3R applications include dissimilar prevention and skilled technics to decrease the capacity of thrower off waste elements. The waste management hierarchy is the universally adopted politics to waste management application and highlights decreasing waste at the resource (Schroeder and Robinson, 2010). So, the 3R hierarchy might become seen quo relating technique to running waste management progression program (Fercoq et al., 2016).

The production of waste and its removal with end-of-pipe means (e.g., incineration, off-site treatment either landfill) is a frequently unwanted result to firm and their stakeholders. Landfill disposal creates expenses to the firm in transportation and disposal prices. Further, symbolizes occasion price having to the reduction of element that has possible reuse value. Waste minimization, preferably than waste disposal, provide a series of advantages on a firm's economic and environmental performance (King and Lenox, 2001). Decreasing waste in operations either reusing waste raw material might decrease prices for firms (Doonan et al., 2005). Simpson and Power (2005) have stated that investments in sources that provide firms to cure their waste minimization performance have results competing benefit. The waste emerging in the system is regularly decreased and sources are utilized higher efficiently, not just prices, client satisfaction rises while higher quality and more economical goods would outcomes, which immediately rises the competing of firms and profitability (Erol, 2012). Implementation of lean production tools connect elements and operations to maximize value adding and reduce waste (Ferng and Price, 2005; Kaswan and Rathi, 2019). Waste management involves reduction, redesign, recycling, recovery and reuse (Li et al., 2005; Fercoq et al., 2016) if source waste management at the corporate grade focus at reducing and eliminating (Womack and Jones, 2010).

Waste occurs in whole steps of the life cycle from design to end of-life (Corvellec, 2016) by the main contributory becoming in design and modification (Osmani et al., 2008). Nowadays, most production firms are in requirement of elaborate report of their waste management system in whole steps of production, and analyzed waste flows to defined occasions for return and source gain (Hogland and Stenis, 2000) So, the primary purpose of waste management in firms discover process of arranging waste management system for a spesific firm, and of achieving an study of the all system (Kurdve et al., 2015; Hogland and Stenis, 2000).

2.1. Identifying of Waste

When the literature is examined more closely, it has been revealed that many dissimilar authors use the term 'waste' differently, so there is large uncertainty with the differentiation of the term in several forms (Thürer et al., 2017).

There are two main points to become mentioned regarding the waste definition: First point that this waste is whichever system input (in terms of converted sources) that cannot be converted into an output that gains value by the clients (met client request, this is not unperformed neither overrun), so, waste is equal to subtraction of system input and output. Secondly point of that in case this waste is requested, wanted, and not met by the client, it is any output or conversion. This description emphasizes a significant subject for lean management system. When it comes to an ideal system, a system that does not contain waste should be considered converting sources and client requirement fulfill in the correct time, in the correct location, in the correct amount, and in the correct grade of quality. But like this a system is improbable to be in fact – when there is a variable (in quality, demand and supply etc.) therefore there will become any waste every time and any amount of variable is unavoidable (Thürer et al., 2017).

Another two value suggestions be in the lean literature by dissimilar effects on the notion of waste: Value described by system input and system output, anywhere any bereavement in value pending the transmutation operations (unproductiveness) is deemed to become waste (Ohno, 1988; Shingo, 1989). Value described with goods and service features (Womack and Jones, 1996). According to Shingo (1989), the issue that causes excessive waste is the inclusion of service features that are not valued by the clients.

Waste is any unneeded actions that do not add value to the product itself, as it rises production costs and reasons waste such as extreme wait and rework, especially in the building and production sectors (Koskela, 1992; Womack and Jones, 2003). Waste might become described as: Every action adds costs yet NVA for the client (Chiarini, 2013). Action into an operation that does not mix value to the client is named 'waste'. Sometime the waste is an essential component of the operations and adds value to the firm and this might not become removed, for example, economic checks (Melton, 2005). Waste is that just rise cost with none added value (Ohno, 1998). When there is production in a firm, it reveals the transformation process of production elements into products and services. This transformation is determined by some another operations and effects of the inner and outer environment. The production process is called an important process that benefits products and services and shows the firm's core business. Waste (losing) refers to any activity (operations, cost and action) that occurs during the application of services or during the production process, that make not suffix value on the product and raises costs (Kučerová et al., 2015).

The description of waste according to Merriam-Webster's online glossary (2017) is as follows. Waste is the loss of anything valued that results from being overused or used inefficiently; Waste is the activity or using that causes redundant losing of anything valued; Waste is what happens when anything of value is not using or is using in a suitable, necessary or ineffective manner (Thürer et al., 2017). Waste is anything business action that does not suffix value during a process flow in the operations of converting inputs to outputs (Hidayati and Shalihin, 2020). Waste is described in any that does not ensure value to clients. The presence of waste also causes an increase in cost and time according to the client's purposes, expectations, and demands (Sutrisno et al., 2018). Waste is something else according to main sources such as effort, material, equipment, machinery, space, parts, labor, and time, which is an important point in added value to the product and for which the client is eager to payment (Sugimori et al., 1977; Russell and Taylor, 1999).

Waste is anything action that sucks sources yet produces no client value (Shou et al., 2020). Waste is the factor of the process that does not suffix value to the product resulting from overproduction, transportation, waiting, defect, stock, redundant processes, motion, reinvention, deficiency of discipline and deficiency of integration of data technologies (Dal Forno and Forcellini, 2012).

Waste is described as an action in the operation that suffix time and costs yet does not value on product and service according to client's views (Melton, 2005). Waste is described as any that prevents the sleek manufacture stream (Bozickovici et al., 2012; So and Sun, 2011). During product improvement, generally, waste is connected by making actions by the incorrect input on the contrary than making redundant actions, as is the case in production (Gudem et al., 2013). Wasteful action is an exclusion so that deflects process from optimal practice (Tomašević and Slović, 2013). Furthermore, in the global, waste for health is winning bigger cognizance and significance (Crandall et al., 2016). Waste caused health problems created lacks which happened in the lack of fruitfulness. This affected firms to fund workforce maintenance and health (Org et al., 2016).

2.2. Identifying of Value

Value is a system that is realized at the correct time and brought the correct price level, gives the top value to task productivity, sustainability, affordability, and performance, and maintains these benefits along its living (Stanke, 2001). Value is a suitable cost and performance (Miles, 1961). The value appears if the whole of the stakeholders agree with (Chase, 2001).

The most important factor in lean thinking is that the concept of value is understood and defined by the client. Value is meeting the needs of the client at a suitable time and price. In short, no matter how value is defined by the client, value is an ability provided to the client at the correct time and price (Womack and Jones, 1996). Value is a product design and production plan that allow the offering to the client of a product that reaches the form, fit, and function wants that the client needs (Chase, 2001). These are as follows.

(1) Form: Information should become in tangible form, clearly saved;

(2) Fit: Information should become (without any problem) beneficial to flow operations;

(3) Function: Information must meet end-user and downstream operations want by a suitable possibility of work (Lean Aerospace Initiative, 1998).

The value is conveyed to the clients thanks to a process, action, either transaction perceived by the client, producing a product related to client feedback and satisfaction (Mostafa and Dumrak, 2015). According to the perception of the client, the value is to offer the product or service that the client needs in a short time and at an affordable price and with high skill. For this, VA activities play an important role and immediately create the products and services that the client needs (Shou et al., 2020). Value begins with a perception of value-based primarily on the wishes and experimentations of the end client regarding the product needed. Then, the value moves upward in the chain of inner (for example, production) and outer (for example, legal clients) clients. Client advantages linked with a product are associated with many complicated, multi-dimensional features besides the meanings and experimentation of a product in daily living (Welo and Ringen, 2016).

Value is a measure from the value of a particular product and service by a client and it is a function of:

(1) Product’s advantage to meet client requirement;

(2) Relative significance from the requirement being met;

(3) Presence of the product relevant to if it is wanted;

(4) Cost of having to the client (Slack, 1999).

The client just wants to pay for products and services that provide them with benefits and value. No payment is made for any actions that are not added-value, and this situation must be deleted completely (Helmold, 2011). For a new product to be added value, (either the basic outputs required to commercialize it) the development activity must proceed in a way that increases the product's profit and market share (Mascitelli, 2011). That is any action and duty that will ensure that the client is both aware of the new product design (either the basic outputs required to manufacture it) and willing to pay for that product or service (Mascitelli, 2007).

Value is additionally an originally mixed notion by concrete and intangible properties that arise from elements changing of production processes to trademark image (Hines et al., 2004; Oliver et al., 2007). The value also depends on its environment. For example in production operations, value is a powerful feature that is over-connected to the throughput of duty than the internal characteristics of the duty itself (Browning and Heath, 2009). However, value is a visible feature of a complex process that exceeds the sum of its parts and does not dissociate completely. The principal sizes of the total value of the product to the end-user might become defined in quality, cost, lead-time, and service (Naylor et al., 1999).

Yet in the lean literature, the notion of value is generally unclearly described (Arbulu et al., 2003; Braglia et al., 2006) and might become debated connected to VA activities (Helmold, 2011).

2.3. Identifying of Waste and Value Concepts

Lean thinking is described as an attempt that, when viewed by clients, results in an increase in value and production productivity through the elimination of waste (Holweg, 2007). As the beginning point of lean practices, since the value of clients has become an important factor of lean thinking, the description of value through dialogue at a particular time, in a particular product, in a particular client, with a particular talent has been adopted (Womack and Jones, 1996).

The value stream principle concentrates on the transparence of whole the bottomed on the client-focused value description, value stream is the set of all the particular activities needed to get a particular product (Stone, 2012), which describes the business operations of activities. These activities take into account the physic and data stream inside the overall value chain. To achieve the value in the production process, the actions in the value flow is classified into three types of activities. These are VA, necessary but non-value adding (NNVA), and NVA (Womack and Jones, 1996).

2.3.1. Value-Adding (VA) and Necessary but Non-Value Adding (NNVA) Activities

VA is a process that provides the fit, function, and form of the product that is required by the end client and realized in the production flow (Shou et al., 2020). These appear to be actions that gain value from the client's view. VA activities are actions for which the client can become ready to payment a part of the final product price (Womack and Jones, 1997). The operations, like the last assembly of a product, that raise the value of the product (Prasad et al., 2018). VA activity is an action of exchanging or treating raw materials toward clients require (Hines and Rich, 1997). VA is regarding converting products and services to clients (Sutrisno et al., 2018). It includes actions that convert the product. They are actions that develop form, fit, and function and are actions that clients are eager to the payment that the product (Kadam et al., 2012). Womack and Jones (1996) described VA activities from a production connection qua stages that really converting the form, fit, and function of the raw material, and make it stage near to the completed product. Liker and Lamb (2000) stated VA activities qua the endeavors spent in converting the input to a throughput that a client needs. VA activities convert materials and knowledge into things beneficial and important, which the client needs in a certain shape at a particular time (Wiese et al., 2015). These activities are actions that convert the materials into the complete product that the client wants (Capital, 2004).

Necessary but Non-Value Adding (NNVA) is anything process that make not provide value however is required to regularize the production operation to raise the value of the final product (McManus, 2005). NNVA activities should be refrained and made as efficiently as probable in order to present a smooth flow of value (Pessôa, 2008). NNVA activities is unfavorable. This inevitable below the present operational processing (Mostafa and Dumrak, 2015; Sutrisno et al., 2018). This waste does not suffix value along the production stream however this action does not become refrained because of numerous causes (Hidayati and Shalihin, 2020). NNVA activities do not form immediate value however are essential to promote value formation, for example, typically government, governance and compulsory test

(Welo and Ringen, 2016). NNVA are activities that do not adding value to the client, but that are redundant to manufacture the product the valid supply and production operations are fully modified. This kind of waste becomes eliminated in a lengthy time however is improbable to become removed in a brief time. For instance, qua a buffer stock, high inventory grades might become needed, however, that would become decreased sequentially qua production be steady (Capital, 2004).

2.3.2. Non-Value-Adding (NVA) Activities

NVA activities, though, is required to provide VA activities below the existing work terms (requisite waste). Namely, ‘waste’ is something else to which the client is not eager to payment (Karlsson and Ahlstroem, 1996). It is a process that does not suffix value to products (Prasad et al., 2018; Hidayati and Shalihin, 2020). NVA are an open waste that must become fully removed. Also, anything production system does not just include actions, but also inputs, throughputs, and tools. Consequently, efficient waste removal must not concentrate only on NVA activities. NVA is a type of action that really wastes and must become removed and reduced at the most immediate (Mostafa and Dumrak, 2015; Hidayati and Shalihin, 2020). Liker and Lumb (2000) stated that NVA activities link to the endeavors funded in the identical conversion operations however do not adding value to the throughput according to a client opinion. Jolley (2004) refers to NVA activities qua the obstructives of systems in the term of waste, variable, and elasticity that add cost with time and cost that does not adding value to the client. NVA activities are actions that are not needed for converting the materials to the product that the client requires. Everything which is NVA might become described qua waste. Anything that provides redundant time, endeavor, and cost are NVA. Test and examining materials are an acceptable waste because this would become removed far for the production operations would become developed to remove errors from happening (Capital, 2004).

NVA activities are redundant and are so described as ‘pure waste’. Imperfect working resulting, in the transport of pieces, inventory, and rework are some of the samples of waste generated in production processes (Womack and Jones, 1997). One of the most common problems faced by firms today is the quantity of waste action that is inefficient or does not add value to the product. Some of the NVA activities are unproductive transportation (which may be intermittent), excessive waiting period, the move of the device and tools that do not fit the capability, ensuring the material procurement of the start to the finish of the operations, and causing inappropriate rework (Hidayati and Shalihin, 2020).

The activity of NVA connects on the actions of the firm. Waste can become described in three important notions: obvious waste, less obvious waste, and buffer waste. These are as follows.

2.3.3. Obvious and Less Obvious Waste and Buffer Waste

The obvious waste involves actions that are not required, unnecessary operations, the unnecessary, recurrent action of staff because of bad store order and business style inventory, rework, times of extreme setup, untrustworthy devices that would become done higher trustworthy that would become removed (Ohno, 1988; Hopp and Spearman, 2004; Soltan and Mostafa, 2015). Obvious waste is the primary resource of extreme buffering and buffering is the resource of waste. But any net factor to distinguish among waste or obvious waste and buffering or extreme buffering is offered. Buffers means are excess capability and inventory. Therefore they are supposed dissimilar of waste. Obvious waste is any waste decreased without forming other kinds of waste (Hopp and Spearman, 2004; Thürer et al., 2017).

Lean has to eliminate the obvious waste and decrease the less obvious waste. Lean processes show performance healing in the fields of cost-effectiveness, conformity of quality, and delivery reliability and velocity. The less obvious waste happens consequently variable resources like delivery and operation times, efficiency and demand ratios, and personnel grades. So, it would replace costly buffers (like inventory) by fewer costly ones (like capability) (Soltan and Mostafa, 2015).

Narasimhan et al. (2006) who indicated that: Last works (Hopp and Spearman, 2004; De Treville and Antonakis, 2006) describe styles of waste minimization involving ‘obvious wastes’ like unnecessary operations, extreme of setup times, untrustworthy devices, rework, and the ‘less obvious’ wastes correlated with variable. It is hard to know how untrustworthy devices are normally connected with variable are obvious waste and not less obvious waste (Thürer et al., 2017).

One waste that is not become decreased without forming other waste is a buffer. If another writers waste is something equal to buffering, According to Hopp and Spearman (2004), waste is not equal to buffering, it is different. Shah and Ward

(2007) clarified that firms typically waste, as extreme inventory or overcapacity (human and devices capability) to make more efficient the effects of variations in supply, demand, and time of the process. Buffers are described by Hopp and Spearman (2004) with the inventory of extreme (stocks of security), the capacity of extreme, and lead time of security. Also, a significant topic is how extreme buffering is determined. The one probability seems to become the level of risk that the administrator is eager to get, which separate inventory, capability, and lead time in a part that is for buffering or safety and the part that is excessive. It is a major source of waste as variability requires buffering. Maybe at other points in the system, decreasing the waste that is because of variability without decreasing variability itself can just lead to the formation of other forms of waste (Thürer et al., 2017).

2.4. Eliminating of Waste

Concept of lean is a continuous effort to eliminating waste to raise the value-added effectiveness of products and services, to ensure and value to the client (Hidayati and Shalihin, 2020). Lean production is also known as the method of reducing waste like recommended by several different writers. However, in practice, it is important for lean production to minimize waste and maximize the added value of products and services. The purpose of lean production is the complete elimination of waste. From the client of viewpoint, waste is not suffixed any value to products and services. These wastes would become described and eliminated or removed by usage lean technics and tools (Gupta and Jain, 2013). Lean achievement should concentrate on the whole of the reasons for waste so, the value stream would work easily so that effective production. VSM is the operation of mapping the stream of data and material required to adjust the actions realized by the suppliers, producers and distributors to give products to the clients. Lean explained that reduced wastage can use the method of VSM, 5S, and Kanban (Hidayati and Shalihin, 2020).

The industry focuses on the minimization of waste and administers operations stream outcomes in organizations using lean concepts to increase productivity (Baysan et al., 2019). In production operations waste generation and as a result, harms to the environment are good researched (Murphy and Pincetl, 2013; Bianciardi et al., 2017). The elimination of waste is the main purpose of a lean concept. Waste or in other words ‘Muda’ is something that is not valuable or is not adding-value. Waste is anything the client is not want to pay as. Efficient waste elimination steps as follows (Domingo, 2015).

Step 1: Perform waste apparently.

Step 2: Become aware of the waste.

Step 3: Become responsible to waste.

Step 4: Evaluate the waste.

Step 5: Decrease and eliminate or remove the waste.

Moreover, before a person would eliminate waste, they must see, know, describe, who brought it up and finally see its size. Invisible wastes cannot be disposed of and stopped. But when waste is rejected, the elimination or reduction of that waste cannot be stopped. If the person does not want to take responsibility for eliminating waste, the waste will remain there. When wastes are not measured, people think they are something insignificant or small, and they will not be willing and motivated to stop or reduce waste. Because what is not measured cannot be cured (Domingo, 2015).

Waste is a major problem in each firm, so, it is significant to eliminate, or reduce this undesired problem. Firms aimed at reducing waste, use existing techniques in a detailed and effective manner, and if these techniques are applied accurately in the process, waste can be removed at all stages of production and development. Implementing these technics is not remove whole kinds of waste, but the right usage of chosen technics would decrease them to an admissible grade (Kučerová et al., 2015). One of the parts of lean management is waste elimination, but it is not the only component. Eliminating waste acts as an impeller in lean management practice (Oehmen and Rebentisch, 2010). Lean concept concentrates on the removal of waste in the firm's production system with constant development and operation exchanges to decreasing NVA activities and eliminates wastes (Minh et al., 2019). Waste elimination means decreasing or cutting the NVA activities from the supply chain operations. Market sensitivity involves perusal (sensibility) and answering (elasticity, speed, and trustworthiness) to the real demand volume and product types (Soltan and Mostafa, 2015).

Conceptional frames for waste elimination advanced. Hicks et al. (2004) offer a general standard for forming the material and stream of waste from cumulative and physical cost aspect. Musee et al. (2007) identified three steps. The first of these are waste resource description and size, the second is, qualifying assessment of waste reasons, and lastly, applicable improving options for waste elimination. At the same time, Darlington et al. (2009), proposed a wasting analysis method adapted to the special wants of food production. These are as follows. During in the production operations, waste inventory analysis to emphasize and observe the resources of waste, conducting cost analysis, making cost management a significant priority, conducting an elaborate environmental and cost impact analysis to reduce, reuse, recycle, and safely eliminate waste. Darlington et al. (2009), have defined a tool to assist with this frame and to remove waste. This tool is Integrated Description method. This tool involves the input (raw material) and throughput (waste) process that provides a physical stream and during the production steps.

Another searchers (Hogland and Stenis, 2000; Maxime et al., 2006) generate alike outputs. These are input and throughput stream, streams of strict ruins, and of materials and power. Decreasing waste is not an VA activities. VA means the reformation of saved up sources. Decreasing waste can independent capacities and decrease cost; but, if the free capacities are utilized to suffix value to the product or if cost savings are cross on to the client cheaper costs are an administrative resolution and detached of the reducing in waste (Thürer et al., 2017). Eliminating wastes would decrease the price of products and increase quality. Actually, even in an effective system that carries out its operations based on waste, it is not possible to eliminate all of the wastes defined as seven lean wastes (Gopinath and Freiheit, 2012). The notion of lean is a sequence of actions and answers that are designed to reduce waste, decrease time wasted on NVA processes, and raise fruitfulness by developing quality, cutting lead times, decreasing costs, and so on (Mason-Jones et al., 2000). This has been one of the goals of lean production goals to eliminate all actions that do not add value. In other words, the practice of this process decreases the waste of goods and services in the production operations and decreases costs (Browning and Heath, 2009; Green et al., 2010).

The elimination of waste raises client value by optimize the usage of sources (Womack and Jones, 1996; Narasimhan et al., 2006). Waste would additionally become associated with client ideas (Arbulu et al., 2003, Hines et al., 2004). Elimination of waste is the principal purpose of anything a lean system. Briefly, the lean approach expresses activity opposite the waste of lean (Baskaran, 2018). Whole actions in production operations that do not suffix anything value to the goods are waste. It is required to discover whole sorts of waste in production operations and propose ideas for their removal (Kadam et al., 2012). For instance, is reducing in lead time related to the reduction of waste in the shape of extreme time (Christopher and Towill, 2001).

Once people know what kind of waste is generated from the processes of firms of all kinds, firms should go the way of improvement and try to eliminate waste (Chiarini, 2013). To decrease waste, it is required to investigate and apply excellence for constant development in the best way (Grasso, 2005). But, in order for waste to be disposed of, it should first become understood that it exists and this is difficult for the anything service industry (George, 2003).

2.5. Types of Wastes

Womack and Jones (1996) describe waste being anything human action that sucks sources yet produces no value (Wahab et al., 2013). The waste producing a lot of unfavorable results like fruitfulness and gain declines, client's discontent, a threat to human living, etc. (Sutrisno et al., 2018). When uncovering and categorizing production, wastes become the primary step in improving a production firm. The description is inefficient when the waste does not become eliminated. For this reason, significant to implement the right instruments, lean production instruments, to eliminate production waste. Defining and categorizing production questions are of important value to a production firm. Correct advances, however, uncover production wastes (Pavnaskar et al., 2003).

The concept of lean is systematically identifying and removal of waste conducing to low process capacity (Shou et al., 2020). Lean wastes use the energy of the whole production system and give big damage to the firm. To happen regular stream of the production operations, lean wastes must become described, graded, and reduced. 'lean' concentrates on removing and decreasing waste (or 'Muda', the Japanese name for waste) and on increasing and exactly using actions that add value from the client's view. Value is equal to any that the client is eager to payment for in the product and the service from the client's view (Baskaran, 2018). Ohno (1988) and Shingo and Dillon (1989) stated that lean concept at the first described value on system input and output, waste is anything lack of cost through unproductive transmutation (usually named 'Muda' - the Japanese name and spent effort or time). The lean wastes, NVA activities, or Muda see the big interest of the administration. Today, the administration is not prepared to carry one waste to influence the industry. Lean wastes produce recession of sources, waste of person energy, and funds. When an operation is a fetter by lean wastes, decreases the production ratio and creates inequality and overload of the work. Like this, a change in the operation influence that whole supply chain. Between the seven lean wastes overproduction is extremely hazardous that creates 3M (Muda, Mura, and Muri) (Baskaran, 2018). Any firm needing progress should avoid actions that have a negative impact on the productivity of the firm's process. This stands for eliminating lack named '3M' as referred with Japanese administrators (Kučerová et al., 2015).

According Dillon and Shingo (1985) and present by Taichi Ohno in 1988, wastes in the production operations would become classified in seven styles. Basically created by the introduction of the TPS to the market in the 1980s seven waste; It is the categorizing of waste and its modes constantly changing, taking into account the versatility of the supply chain and firm-level TPS or Lean Operating System, operating in different areas such as product, service and software development. These include; Overproduction, Waiting, Motion, Transportation, Overprocessing, Inventory, and Defects (Sutrisno et al., 2018; Aka et al., 2019). It must become considered that the principal purpose of each producer is to give goods quickly at a low price to do not compromise the specific standard (Holweg, 2007). For this reason, tactics that would become applied to reduce these wastes and their following negative effects in the production operations are the topic of many types of research. As a result, searchers have examined wherewith kind wastes would be removed by the practice of lean notions in the global (Osmani, 2011; Al-Aomar, 2012; Nagapan et al., 2012; Koskela et al., 2013; Ko and Chung, 2014).

Production waste is produced on the production operations (Fercoq et al., 2016). Production waste involves nine kinds. These are overproduction, waiting, motion, transportation, overprocessing, inventory, and, defect (Dieste et al., 2019); health of people (Org et al., 2016); and area crucial to production operations (Yafei et al., 2018). The initial seven kinds created the fundamentals of the lean concept. In the global, waste because of health is winning higher cognizance and significance. Long time in business immobility reasons hazard of health, be the result of waste, like problems of musculoskeletal, illnesses of cardiovascular, and raised death rate (Crandall et al., 2016). Waste because of health problems produced failures that occurred in the lack of fruitfulness, which affected firms to fund labor force maintenance and health (Org et al., 2016). Field waste involves having more according to the optimum field required as machines, materials, motion and men (Yafei et al., 2018). Also, performance standards decrease if the warehouse field is utilized for undesired, junk, material and more inventory, increase warehouse prices, and handling (Shah and Khanzode, 2017).

2.5.1. Muda

Muda tries out to remove anything waste by the lean production theory (Kučerová et al., 2015). Muda is NVA activities (Baskaran, 2018). The term Muda means to loss and waste (Kučerová et al., 2015). This is the Japanese word on wastage. Removal of wastage in the lean concept is significant in stopping that. Value is the reverse of waste. Decreasing waste does not certainly decrease prices. Waste minimization would become changed to price decreases in the consideration of the system. Waste is too categorized in various styles (Bicheno et al, 2011). Muda is a high capability according to workload (actual loss-waste) (Chiarini, 2013). As the characteristic of this type of waste, it is said that time, money, and resources are used in vain without any added value for the client. The purpose of defining Muda is about which steps are required in the process and which ones should be reduced and completely disabled. Due to waste of time, money, or resources during activities and activities that do not add value, the firm unnecessarily loses material and energy in terms of workforce and machinery. Muda makes it difficult to deliver the product at the right time and causes time losses (Çanakçıoğlu, 2019).

Ohno (1988) is described seven kinds of waste that are accepted like Ohno’s seven Muda. These are overproduction, waiting, motion, transportation, overprocessing, inventory, and defect (Wahab et al., 2013). These seven wastes will be explained in detail in 2.5.4.

2.5.2. Mura

Mura is the Japanese word for inequality and disorder (Kayanda, 2017). Mura refers to overload (Baskaran, 2018). Mura is overload, plant, equipment, and human sources exceeding their own sizes. That might generate extreme tension, fault, downtime, lag, and calamity (Domingo, 2015). It is monotony and deflections. Mura describes the erratic usage of an individual or a device. It would become found in anything operation fluctuation, which must become decreased and removed for preventing the probability of Muri in anything value add production source (for example, a machine tool, a robot, a computer, an operator, etc.) (Ohno, 1988). Mura is highly linked together with Muri and Muda. Operation's surges are associated with its variability, and in order, form circumstances that create waiting and tails. Muda and Muri emerge with one or more excessive use of production sources at certain times and stages of operations. In order to eliminate such variability in operations, it is desirable to create buffers and stocks (Romero et al., 2019). Mura is caused by two different reasons such as the change in the production schedule and the unbalanced distribution in the pace of production. The main reasons for Mura are batch production used by many firms. Because firms that produce in batches often create a buffer stock by producing more units of goods than necessary in order to protect themselves against changes in demand. While trying to meet and balance the changes, they cause fluctuations in production volume that are only beyond their own wishes. These continuous changes in production volume actually reduce the productivity of employees and increase the probability of machine failure and these reveal Muri. It also reveals all other types of Muda and this situation occurs as the chain relationships that cause Mura to create Muri and then both of them give rise to Muda. This relationship, for example, changes in production volume sometimes forces the firm to overload and under-use its resources. It creates Muri and leads to overproduction. This causes interruptions in production, errors, returns, and waiting times, causing other Muda types (Pieńkowski, 2014). The production leveling is utilized to stop that issue. Dissimilar grades of inventory in order to recycle for instance may cause a workload of unbalanced and cause waste of sources, especially human power (Kayanda, 2017). Mura is a capability that turns round the constant goal (the waste is not steady) (Chiarini, 2013).

2.5.3. Muri

Muri notices inequality in production capacity. The bad surges for excessive-high (summit) and low (valleys) in production programming reason times of overload and extended of idle time (Domingo, 2015). Muri is excess and overload (Kučerová et al., 2015). Muri is over workload according as capability (staff and devices very engaged) (Chiarini, 2013). Muri is described like the illogical load of operatives and equipments. It relates to anything activity that links concrete-physical and abstract-psychologic anxiety status. Samples of Muri involving operatives are tilting to working, lift severe weightiness, and repeated exhausting physical and mental activities when taken deadline that is frequently very small to the staff's individualistic ability grade (Arezes et al., 2010). Therefore, the connected be of most production operations would reason Muri, particularly while very much or much Muda is lifted of a particular location in an operation (for example, over-optimum). Consequently, Muri reasons Muda with the extreme device and human usage and associated breakdown and errors, and due to extreme optimum in an operation (Hampson, 1999; Romero et al., 2019). For instance, it ensures that strict rules are set for the conduct of business actions. it enforces the workforce to work in restricting and estranging conditions that create stress and strength (De Treville and Antonakis, 2006). Muri are linked to waste due to excessive workload, which is beyond the capacities of the equipment, facility, and labor resource. Overloading the workload reduces the skills and capacity of the employees to get the job done and causes the unnecessary workload of the machines. Muri has the three most important reasons. The first is an inadequate, poorly, incorrectly, and improperly organized or designed layout. The second, incomprehensible instructions, inadequate communication, lack of care standards. The third is the change in the amount of production, in other words, the formation of 'Mura'(Çanakçıoğlu, 2019).

A road to decrease Muri is to apply production grading (Domingo, 2015). Muri explains it as illogical and very hard or extreme. This kind of waste is referred with thanks to standardization, linking basic processes to create an effective system. Stream of working and rationale by provided takt time would become extremely beneficial in a good production plan which would better efficiencies (Kayanda, 2017).

Generally; Muda, Mura, and Muri reason unproductiveness and big prices in anything process (Domingo, 2015). Schonberger (1982) described Muda as essentially a lack of quality. Mura and Muri notions are described as variability and extreme (for example, give an order very much of outer supplier), sequentially. Muda turns immediately to waste and Mura and Muri are turning into discrepancy and unlogical in the English version of Ohno’s (1988) working. Harrison (1992), in the literature, Muda is seen to become waste. But mura and muri are accepted to become resources of waste, circumstances that cause the formation of waste (Thürer et al., 2017). In the systems, there are Muri and Mura wastes as well as Muda wastes. The plain thought, which is the antidote of Muda, is not only about the prevention of Muda, but also the destruction of Mura and Muri. It is necessary to define waste not only as Muda but also as Mura and Muri. Because in order to completely eliminate the waste in the processes, it is necessary to define the relationship between these three concepts together (Pieńkowski, 2014).

2.5.4. Seven Lean Wastes of Lean Production

Lean production eliminates actions and waste that do not add value to a production process. In lean production, waste types, also known as Muda, emerge as seven types of lean waste. Lean seven wastes are overproduction, waiting, unnecessary or excess motion, transportation, overprocessing or excess processing, unnecessary or excess inventory and defect. These types of wastes are explained below.

2.5.4.1. Waste of Overproduction

Overproduction is a kind of waste that occurs very surplus, very premature, and just in case. Ohno considered that this kind of waste was the most important waste as it posed a lot of issues and caused another waste to emerge as well (Womack and Jones, 1996; Wahab et al., 2013). Overproduction is the riskiest and important type of waste that the production and service sectors have to tackle. If there is a range of products that overrun demand, it means they are produced very quickly or very early. As a matter of fact, there is a simple rule in the production sector. This is the production situation that occurs when there are no client orders if overproduction occurs. Many executives consider that these products stored up in warehouses will one day become purchased. There is an attitude that products will be purchased, especially in line with the estimates improved by a Materials Requirement Planning (MRP). But would the firm become certain that these orders would reach the client. By the way, the firm spends money and the storage rooms fill up, thinking that there would become no damage, theft, and wear (Chiarini, 2013).

There are many causes for overproduction waste to occur. Some of these are usually associated with: Production of big size economic parts; Producing before and after the demand; Low rate of installations; Provide inventories to eliminate deficiencies; Staff redundancy in the process; The presence of excess or fast machines (Chiarini, 2013); The capacity be encouraging (selling, payment, buying); Big size pieces of equipment; Route unbalance; bad shifting and timing; Bad production projection; and Cost accountancy applications that support the formation of inventory (Domingo, 2015). Overproduction causes a lot of negative results. The most important of these are high inventories (waste of secondary) (Chiarini, 2013; Al Mouzani and Bouami, 2019); slow of the production operations; decrease of plan elasticity; and rise of indirect expenses like transportation, controlling (Chiarini, 2013).

Overproduction happens when more products are produced than the planned quantity in a production plan and produced more quickly (Capital, 2004; Kadam et al., 2012). The results are chunks of premature deposits in the interim warehouses. It is to start processing the next operational orders directly after finishing the previous operational orders to stop a worker on a machine in a production line from being unemployed. This is expected to produce or process the new product, ie the next process, but by doing this the worker creates overproduction that requires intermediate warehouses (Kadam et al., 2012). In this case, it happens if the transactions continue after they are finished. Because this creates excess inventory or excess product or premature production (Hicks, 2007) Parts are produced without a client request or a new order (Capital, 2004). In this case, overproduction causes overwork in a process (Hines and Rich, 2007). For instance, large batch size, unstable cells, and programming, wrong data on-demand lead to overproduction (Arunagiri and Gnanavelbabu, 2016). Overproduction is extreme that took time, money, workers extreme working, and extreme inventory, etc. things (Chahal and Narwal, 2017).

Overproduction is producing a product before it is needed. This is very costly for a production facility because it prevents the flow of materials from being smooth and reduces productivity, efficiency, and quality. The TPS is also known as JIT because every part is done just in time and exactly as required. Overproduction is called ‘in any case’. It causes longer delivery times, increased storage costs, and does it hard to identify mistakes. A resolution to overproduction can be called closing the tap. But this situation also requires courage for firms because problems under overproduction will come to light. The aim should, in fact, be to plan and manufacture products that will be sold and shipped immediately, and to improve machine replacement and installation capacity (Sheikh Sha Alam et al., 2019). Because excess or premature production results in a poor flow of goods and information (Womack and Jones, 2003). Overproduction waste is that the firm requires to consume additional time and area to warehouse the completed products. Overproduction might influence the product quality and the completed products. Moreover, overproduction causes large inventories and the consequence of that is to cause despair and bad relationships of the workers (Bichero, 1998).

Overproduction causes excessive raw materials used in the production of undesired parts, extreme use of dangerous materials that cause excess emissions and elimination of waste, and therefore excess energy consumption (Hallam and Contreras, 2016). This can be explained as follows. There is a possibility that extra products might deteriorate or these products may become old enough to be discarded. The extra dangerous materials used also cause extra waste and removal of waste (Fercoq et al., 2016). In overproduction processes, the next process is produced more or earlier than it can be used. These processes are divided into two as ‘redundant processes’ and ‘unsynchronized processes’ as sub-processes. The redundant process refers to anything compulsory process output that is not required in the processes and does not provide benefits and must diverge from the useful process. Unsynchronized processes mean that the given process throughput cannot become utilized immediately due to insufficient capacities and a lack of another material needed to continue the process (Pessôa, 2008).

Overproduction is generating more than necessary, and it does so very quickly. If more products are produced than the products sold, this will cause the finished product inventory to be empty. Overproduced products often appear as hidden waste. Because these products are considered valuable, but can actually become obsolete and inefficient. Unnecessary costs arise, as firms stay with these products until they get them out of their dispose of. JIT system, Kanban system and pull system reduce overproduction waste. In addition, the lean concept prefers to use small equipment instead of large equipment in order to refrain over and unnecessary production

(Domingo, 2015).

Overproduction produces more than what the client is currently asking for. This is a problem that prevents the stream of information and products. Unproductiveness and quality loss occur (Prasad et al., 2018). In fact, such wastes originate from the policy of progress in the production process. The number of products required for an efficient flow of a production volume is ignored (dos Santos et al., 2008). Because overproduction is excess because it produces products too early or too much than the required quantity according to the determined production schedule (Hidayati and Shalihin, 2020). It leads to a waste of people's labor, materials, and energy (Kučerová et al., 2015). Overproduction raises the risk of aging, raises the risk of production the incorrect item, and raises the probability of becoming to sell these things at a reduction and throw them qua junk (Capital, 2004). It influence the stream of the operations and adding extra labor force, and cost of material to the product (Thurston and Ulmer, 2016). This is the production that is done without any demand (Antony et al., 2015).

Furthermore, the advantage of overproduction is that if firms do not produce too many products, they use less raw materials and utilize low energy to work in operations. They avoid the risk of not selling the overproduction of inventory and disposing of it as waste finally (Hallam and Contreras, 2016).

2.5.4.2. Waste of Waiting

Waiting waste is entirely linked to flow and is likely the secondly most significant waste type. This type of waste manifests itself if time is not utilized effectively. These wastes are created in a factory when products are not acting. This influence products and workers (Wahab et al., 2013). Waiting is the potential degradation of the material, and the component produce waste (Fercoq et al., 2016). Bicheno and Holweg (2000), stated that waiting is linked to lead time, which conduces to client satisfaction and competitiveness. There is a waste of waiting when the products are not acting and processed. For example, a product will spend more than 99 percent of its life in traditional tail and batch production waiting to become processed. The lead time for a product is related to waiting for the other operation. This is because of the long distance among work hubs, bad material stream and production processes take very long (Sheikh Sha Alam et al., 2019). John Bicheno (1998), stated that waiting is inimical of the regular-stream. Occasionally, the cause that happens to wait, is the bottleneck because the cycle time of operations is very high compared to the cycle times of another machines in the production route. Therefore, the after operations have to wait till the ‘bottleneck’ duty ended. Goldratt (constraint theory) stated that any hour lost during the bottleneck process is actually one hour lost in all factory throughput and this situation will not be compensated. Connecting processes jointly that a process nourish directly into another significantly decreasing waiting (Sheikh Sha Alam et al., 2019).

Waiting time would become secret or visible. If a worker is operating the only machine with an automatic arrest and feed device, this is a visible waiting time (Kadam et al., 2012). Waiting is having to wait before taking the next action. Waiting time is related not only to the activities of the workers but, at the same time, to the operations performed by the machines. In the production sector, as in public management, it is the same and common to see workers stand in front of machines and wait for a transaction to be completed, just as a meeting is canceled if no document has come. In a bad scenario, it is the need to search for documents and tools that are not readily available and the associated downtime. Waiting is likely, the most adopted kind of waste. Usually, waiting waste is accepted except for machine malfunctions caused by damage to the system. Standing in front of a machine, which is the responsibility of the workers, is considered to become the supervisor of that machine, but it goes unnoticed that the worker can make other activities in the meantime (Chiarini, 2013).

There are many causes for waiting waste to occur. Some of these are usually associated with: Extended time of immobility to human, data or products, cause the bad stream and high lead times (Soltan and Mostafa, 2015); Shortage of procedures and instruction; Shortage of equilibrium among actions; Large pieces in production; Shortage of order and cleaning; Inefficient protecting care (Chiarini, 2013). Overstaffing; Unsynchronized operations; route inequality; Workforce of unbending; Extended setup time; Unplanned machine fault time; Human power famine or lag; Material famine or lag (Domingo, 2015); and cut in production pending the exchange of shift or because for mistakes happening in the waste of time and raises prices of goods (Prasad et al; 2018). Lifting these causes would become made as follows: Developing order; Balancing of production; Cleaning and order (5S); Predictive and protective care; Error prevention the systems (for example, Poka-Yoke); and Fast transition (Chiarini, 2013).

Waste of waiting is an empty time for workers and machines because of bottlenecks and a falsely designed production stream (Capital, 2004). For instance, waiting is an extended change operation, an untrustworthy operation, and the time needed to make rework (Arunagiri and Gnanavelbabu, 2016). This type of waste is also known as queuing. This happens if there are periods of immobility also at the time of the downstream action if the upstream action is not given on time. These empty downstream actions are utilized in a way that does not add value and causes overproduction (Hicks, 2007). It is an inefficient and long-lasting waste when moving from one action to another. There are types of waiting waste, business plans, parts of the machine, e-mail, and order, and so all are waiting waste (Chahal and Narwal, 2017). This turns into waste as the waiting waste is waiting for the next action. In other words, because it expects the stream of the product in the prior operation, a type of waste arises where the workers do not utilize time efficiently to add VA activities to this product (Hidayati and Shalihin, 2020). Waiting waste can occur due to a shortage of equipment for product ingredients and unbalanced production and damage machine (Kučerová et al., 2015).

This waste arises if a worker’s hands are empty, that is, imbalances occur to the production schedule, when the machines are down, in the product is missing part, or if the worker is watching the machine doing a value-added job (dos Santos et al., 2017) Therefore, waiting waste is an empty worker and machine wait. Loss of waiting time occurs when there is unnecessary waiting due to delays in the come or availability of resources, information, and another source such as workers and equipment. To give the example of this waste, waiting for vehicles to begin work, waiting for tardy participants for a conference, waiting for an autograph for an operation to be, waiting for the vehicles to take the workers to other project locations (Domingo, 2015). This waste is a very obvious waste. Because a lot of time is consumed waiting for the products and information, causing in longer lead times (Al Mouzani and Bouami, 2019). Waiting waste is associated with the constant value concept of processing time. Therefore, the flow of value resulting from the deficiency of required sources and inputs is defined as non-flow. Waiting waste is divided into two sub-types. These are described as ‘scheduled wait’ and ‘unscheduled wait’. The scheduled wait would become scheduled during scheduling when resources are scarce, the buffer is added, and duties are sequenced. The unplanned wait, if there will be a visible wait, if different from the designed stream, it goes into unplanned wait. More visible waiting, though, is the unscheduled waiting, when the execution differs from the planned flow (Pessôa, 2008).

Cooling, heating, and lighting occur throughout the production process. Therefore energy is wasted and this leads to waste. Therefore, as an advantage of waiting waste, by decreasing waiting waste, production latency is reduced and firms spend less energy (Hallam and Contreras, 2016).

2.5.4.3. Waste of Unnecessary or Excess Motion

This type of waste has a connection with ergonomics and this connection is bad ergonomics (Rawabdeh, 2005; Sheikh Sha Alam et al., 2019). This is the part of the ergonomics link since there is a powerful relation among machines and humans in this kind of waste (Chahal and Narwal, 2017). It occurs when walking, lifting, stretching, and twisting. This waste poses security and health problems and becomes a risk for organizations. Therefore, processes requiring excessive movement must become examined and improvement studies should be carried out with the participation of the facility staff (Sheikh Sha Alam et al., 2019). It refers to excessive movement waste, layout, and people. Movement, stretching, bending, and lifting of employees while performing their work should be related to the structure of the production order. This can tire employees, resulting in lower productivity and deterioration of quality characteristics. This waste is also generated by poor workplace regulations (Wahab et al., 2013).

The actions of the workers while placing or holding the products create this waste. The main component in an assembly line is a conveyor belt. This band can be defined as the waste generation and accumulation location. For example, workers sit next to these belts and do their work, assemble parts, and do not get help from other workers. Because they always sit and have a limited range of motion, waste accumulates. This situation would become resolved by ceasing to work on conveyor belts and switching to U-shaped production lines. Sometimes workers can be worked with one hand in production activity and this arises as a problem (Kadam et al., 2012).

If there are no skilled workers, some workers may be moved from one place to another for this. Workers can be moved to input data into the software. A vehicle in the factory can be moved to be searched by workers. In these research, it was observed that the unnecessary or excess motion waste takes time and all this reveals the relationship between the waste of time and unnecessary or excess motion waste (Hicks, 2007; Chiarini, 2013). For example, if an operative has to make a lot of duties, where each duty is requiring to the dissimilar machine, then the machine has to adjustment ergonomic in the job place to refrain bad fruitfulness and unforeseen movement with the operative (Liker, 1998).

There are many causes for unnecessary or excess motion waste to occur. Some of these are usually associated with: Dimension of the big batch; Bad business structure; Process project (Arunagiri and Gnanavelbabu, 2016). Shortage of abilities and bad education of workers; Rise in worker and working times; Inefficient worker engagement; Actions made in private spaces (Chiarini, 2013); Bad layout plan and irregular working place and areas of storage; Shortage of order and cleaning (Chiarini, 2013; Domingo, 2015); Uncertain, no standardized working instruction; and uncertain operations and materials stream (Domingo, 2015). To eliminate unnecessary or excess worker motions the following exchanges require to become done: Examine directions and operations; Make U-shaped conveyor-belt; Raise knowledge regarding motions; Develop operator’s abilities and education; and the orderly workplace (5S) (Chiarini, 2013). Therefore, unnecessary or excess motion waste can be reduced by doing the following. There can be less conversation between workers during work. The necessary tools to be used can be placed in an orderly manner. Organizing all files and data in one correct place. Motion can be less when receiving machine parts and tools. If the arrangement of the machine and its parts is good, the movement can be less (Chahal and Narwal, 2017).

Unnecessary or excess motion means areas occupied to hold excess inventory, overproduction, rework, and inefficient settlement through equipment and workers. In addition, it does not have a feature that adds value to the product and service (Hicks, 2007; Hidayati and Shalihin, 2020). Unnecessary or excess motion waste is occurred by equipment and people who walk and move a lot to carry out a production process (Antony et al., 2015). These unnecessary or excess motion cause an inefficient flow of goods and long delivery times (Prasad et al., 2018; Hidayati and Shalihin, 2020). It removes employees from the actual product that needs to be processed (Capital, 2004).

Unnecessary or excess motion waste occurs as unnecessary or excessive body motion when making a job or task (Domingo, 2015; Al Mouzani and Bouami, 2019). If the workplaces are disorganized and messy, it creates waste when workers are searching for the documents or tools they need. Thus, this waste delays the start of work and causes disruption to the workflow (Domingo, 2015).

This waste would become divided into ‘remote locations’ and ‘bad information systems’. Because of these, information flow, tools, techniques, and equipment are not understood, they exit the optimum process and are expressed as unnecessary or excess human motion (Pessôa, 2008).

Unnecessary or excess motion waste needs more area rising, lighting, cooling, and heating demands. With rising energy needs, the production time of a product can rise. This can generate waste. About this, as a benefit of the unnecessary or excess motion waste, the following can be considered. To reduce energy waste in the workplace, the effort to move something unnecessary can be reduced. The movement of walking back and forth to do a job or find tools can be reduced (Hallam and Contreras, 2016).

2.5.4.4. Waste of Transportation

Transportation waste occurs as a result of temporary storage, handling of pallets, loading, and unloading, very long, and crossing transportation routes. Process failure and overdone division of labor occur due to undefined interim warehouses and mass production (Kadam et al., 2012). In this researches, waste of transportation is expressed as unnecessary movements of products between processes (internal and external movements) on the way from one place to another and does not add value to the products (Capital, 2004; Hicks, 2007; dos Santos et al., 2017; Baskaran, 2018; Prasad et al., 2018). Transportation waste manifests itself as it goes or comes between stockpiling areas and warehouses, from one warehouse to another activity. Transport and vehicles are therefore used in a production system. Moreover, moving the excess stock level results in a high transportation cost (Chiarini, 2013). Anything motion of people and materials round a facility that does not attach value to the products and services is acceptable as a waste of transportation. So, the move of materials, completed products, pieces, or knowledge much than needed resulting in spent endeavors and power and attaching to cost. Paper-work return, big batch reworking, various warehouse areas, and shortage of job place enterprise will cause transportation waste (Liker, 2004).

Transportation is the movement of work or materials being processed from one workstation to another using tool such as a forklift or conveyor. Transportation is important and indispensable in the production process but it does not add value to the product. This waste should be minimized as it does not add value to the product (Kučerová et al., 2015; Hidayati and Shalihin, 2020). Cost and time are used a lot (Soltan and Mostafa, 2015; Chahal and Narwal, 2017). Moving from one place to another causes damage and loss of quality occur. Material handlers, for example, are responsible for handling materials. This situation results in cost as it does not actually add value. It is both difficult and costly to determine which processes the processes will go and bring processes and equipment closer together. This may be more visible if product streams are mapped (Sheikh Sha Alam et al., 2019). Transportation waste would mean become qua extreme move of people, knowledge, and products happening in spent time, endeavor, and cost. The idle time if the product is in the lorry, train, and vessel, for instance, attach prices to the firm no attaching anything value to the chain (Mangan et al., 2008).

There are many causes for transportation waste to occur. Some of these are usually associated with: Big batch capacity; Many warehouse places (Arunagiri and Gnanavelbabu, 2016); Very big orders; Bad layout plan; Believing that transport and handling are unavoidably portions of the operations; Workers with bad or restricted abilities (Chiarini, 2013); Far suppliers; Bad way plan; Route unbalance; Complicated material streams; and Irregular working place (Domingo, 2015). Lean production tools can be effective in reducing transport waste as follows. Utilizing very ability workers; examining the stream by Spaghetti graph and VSM; and U-shaped cells (Chiarini, 2013).

In general, transportation waste is divided into four sub-headings: due to change of location, structural barriers, information barriers, and business continuity barriers. Transportation waste occurs when overcoming structural barriers and relocating materials and information. In addition, this type of waste consists of the form of ‘loading and discharging’ information to a person, because of barriers of continuity (for example, excess of tasks or deduction) and barriers of information (for example, the requirement to learning) (Pessôa, 2008).

Transportation waste occurs when it is transported from one place to another by the unnecessary movement of equipment, tools, and people. Examples of this situation are the following. Examples include sending documents that must not become sent, transporting the incorrect pieces and failure, sending products at the incorrect time, and to the incorrect location. As a method of reducing these wastes, it is the service provided to clients with a short distance from suppliers. Alternatively, the tool and material sections are moved and pre-placed in the user areas or near or adjacent to their internal clients. Thus, the sections that work with each other reduce transportation waste (Domingo, 2015) and generally reorganizing the design decreases transportation waste (Chiarini, 2013).

The process of double-handling and the motion of materials creates transportation waste and quality and productivity decrease (Bichero, 1998; Wahab et al., 2013). Excessive packaging may need to be transported and motion in order to prevent any damage to the products during transportation (Fercoq et al., 2016). Transportation waste causes excess emissions and energy. Related to this, as a benefit of this waste, if transportation is reduced, both emissions decrease, product-related costs decrease and energy also decreases (Hallam and Contreras, 2016).

2.5.4.5. Waste of Overprocessing or Excess Processing

Overprocessing or excess processing waste means that processes and machines do not have a certain quality. If processes are realized with certain standards, methods, and training that do not include any errors, they become able. This waste arises when large inelastic machines are preferred over the purchase or use of a few small flexible machines. This is a complicated process. Employees are directed to overproduction to compensate for the investment in large inflexible machines. This results in bad communication and excessive transportation. This type of waste should be reduced, having the smallest flexible machines and being next to the previous and next processes to produce the necessary quality (Wahab et al., 2013). Most firms utilize high costly and precise equipment, thinking that simple machines are enough in the process. This is the result of bad residential as there is a distance between the previous and the next processes. Toyota is known for using well-kept old machines and inexpensive costly automation. That is when production cells are created and processes combined using small and flexible machines, this is a step towards reducing the type of waste (Sheikh Sha Alam et al., 2019).

This waste is actually a product resulting from badly prepared production. It is a situation that does not meet the product needs, needs to become reworked, and sometime does not work (Kadam et al., 2012). Overprocessing or excess processing waste is an action caused by the use of materials that are unwanted by clients and unnecessary in the production process. The link between overproduction and overprocessing or excess processing waste is as follows. In the overproduction process, if a worker operating the machine sends the product to the other worker for the next process, if that worker is not ready to process those products, overproduction occurs as the products continue to accumulate in the WIP. But the work done by the machine here is not superfluous. When the next worker controls or bloc the process halfway through, then excess processing waste will occur. This waste would become removed utilizing processes and procedures, making this process effective. Also, all workers must become informed about this issue. As process improvement steps, new procedures would become advanced, a team would change the stream of production, but at the same time, informing working workers on this issue would be overlooked (Chiarini, 2013). Overprocessing or excess processing waste is the use of incorrect systems, tools, and processes rather than utilizing a process that should become easier (Soltan and Mostafa, 2015).

Overprocessing or excess processing waste is the use of incorrect systems, tools, and processes rather than utilizing a process that should become easier (Soltan and Mostafa, 2015). There are many causes for overprocessing or excess processing waste to occur. Some of these are usually associated with: Many engineer modifications; Uncertain client features; Uncertain procedures of working; (Domingo, 2015); Operating on the unsatisfactory elements; Unsatisfactory tools, machines, and automation; Missing uniformity of action; Unsatisfactory design of operation; and Unsatisfactory analysis of action (Chiarini, 2013). Therefore, eliminating waste would become made as follows: Implementing techniques like Value Engineering (VE) and Unsatisfactory Value Analysis (VA); Reviewing and publishing directives and practices; Mechanizing of duties; Reviewing and publishing directives and practices; and Replanning the operations (Chiarini, 2013).

Overprocessing or excess processing waste is an unneeded activity that does not add value to products, which are products that are produced or processed. This type of waste emerges as a quality that the clients do not want, and as extra actions that do not increase the quality of the product. An unneeded documenting is actually an excessive processing waste. By utilizing methods like a diagram of waterfall and analysis of value flow, what adds value, what does not add value, these actions can be determined (Domingo, 2015). Unsatisfactory technology use also occurs with excessive processing actions. Sometime it is seen that these processes cannot be synchronized and this waste comes out if workers reach performance grades far past or under their downstream operations needs (dos Santos et al., 2017).

This waste occurs when a worker is doing too much work on the machine and over working a work piece. This consumes time and increases costs, in relation to the attitude of the worker (Chahal and Narwal, 2017). So, overprocessing or excess processing waste is human processing without added value and machine processing without added value (Domingo, 2015). In addition, if the working techniques and a business process used in a process are very elastic, if the processes do not flow according to a certain standard, the number of incorrect products increases, and thus processing waste occurs (Hidayati and Shalihin, 2020).

In these researches, it is explained that, beyond the client's need, this processing waste is occurred by more processing (Capital, 2004; Chiarini, 2013). Overprocessing or excess processing waste is a type of waste that is unwanted by the client, utilizing operations, practices, unsuitable tools, utilizing equipment of big size, and does not add any value to the client (Antony et al., 2015; Al Mouzani and Bouami, 2019).

Overprocessing or excess processing waste happens due to operations like storage and transportation, errors, extreme inventory usage (Hicks, 2007). This waste means doing the unneeded tasks in a process. This waste divided into three subcategories. These are, 'too much engineering'- happening beyond certain conditions; 'data transformation'- transforming data between people and between information the systems; and 'reinvent'- inventing something that can become easily reusable or adjusted (Pessôa, 2008). Overprocessing or excess processing waste includes extra spending of pieces and raw material per monad of production, raised waste, utilized of energy, and emissions. Therefore, if the processing process is developed as required, firms also reduce their ecological footmark and waste (Hallam and Contreras, 2016).

2.5.4.6. Waste of Unnecessary or Excess Inventory

In the studies conducted, it has been explained that unnecessary or excess inventory waste actually shows characteristics similar to overproduction waste (Kadam et al., 2012; Chiarini, 2013; Domingo, 2015; Sheikh Sha Alam et al., 2019). Because waste from unnecessary inventory and too much production arises just as with overproduction. High costs depend on storage. Because the costs incurred when products leave the warehouse consist of order initiation costs, inventory costs, material, and product purchasing costs. There is a chance that a product is more than 20 percent of its selling value. This type of waste is reduced by determining the desired amount, the time when the ordered product enters the warehouse, rather than less, more, or optimum inventory (Kadam et al., 2012). Unnecessary or excess inventory waste arises from the storage of extreme materials, exported items, purchased items, and another sources (Domingo, 2015). This waste can manifest itself in the storage or delay of information as well as the storage of excess products. This leads to bad client service with unnecessary inventory and high costs (Soltan and Mostafa, 2015). Because this type of waste is extreme storage that utilizes sources but does not attach value to the clients (Al Mouzani and Bouami, 2019).

Unnecessary or excess waste of inventory means replacing the product of an WIP with faulty material, storing waste resulting from damage and deterioration of products, and further packaging for them (Fercoq et al., 2016; Hallam and Contreras, 2016). Inventory is a product or raw material that is stored inside or outside the institution for a specific time. Inventory can consist of raw materials, semi-finished products, or finished products. If the product is wait to become processed, this product is in (WIP) process and this kind of waste is determined by looking at the piling point of the products (Chiarini, 2013). Inventory is an extreme warehouse of products shaped of raw materials, work in progress, and completed products, raising the cost of operation (Prasad et al., 2018). Also, inventory keeps the store of products as stocks of safety (Baskaran, 2018). Unnecessary or excess inventory is the store of goods including not orders (Capital, 2004). Unnecessary or excess inventory waste is excessive processes inventories and excessive raw material inventories and materials

(Domingo, 2015). It also arises as a consequence of unnecessary stock waste, works in progress, and waiting. Unnecessary or excess inventory is a way to conceal issues in a factory. Because it is necessary to be able to describe and solve that develop performance (Sheikh Sha Alam et al., 2019). It rises delivery times, makes it difficult to find out what the problems are, and reduces productivity (Wahab et al., 2013; Prasad et al., 2018; Sheikh Sha Alam et al., 2019). However, some firms manage to reduce inventory and costs by streamlining business centers, making producer and client improvements (Sheikh Sha Alam et al., 2019).

There are many causes for unneccesary or excess inventory waste to occur. Some of these are usually associated with: Admitting that unnecessary inventory would not become prevent because of it stands for direct transfer to the clients; Long transition times; Bottlenecks in the production and service application stream; Manufacture of premature; Operations at the start are faster than those close to the ending; Pieces of the operations that form are unproductivity and generate errors; Production large economical parts (Chiarini, 2013); Extreme inventory, big quantity capacity, lengthy changing; (Arunagiri and Gnanavelbabu, 2016); Uneven route; Overproduction; Regional optimum; Long delivery times; Loud reprocessing ratio; High minimal order amount; Shortage of demand for material and arrangement norm; and Suppliers of insufficient (Domingo, 2015). Unnecessary or excess inventory conceals issues, no resolve them. Therefore, the following lean methods can be applied to eliminate unnecessary inventory waste. U-shaped cells and using group technology; more useful stabilizing actions; Quick changeover operations; and Pull production by utilizing the Kanban system (Chiarini, 2013).

This waste manifests itself by using inventories that are not needed to meet existing client orders. All of these inventories require fields and extra transactions (Hicks, 2007). In a push system, if there is no product order and the system works as such, excess inventory occurs (Chahal and Narwal, 2017). For example, stocks are lesser required materials. But when there is a large amount of inventory, it requires an excess area to store between jobs in the process. This occurs as a high buffer waste (Hidayati and Shalihin, 2020). Other example, the store up of heavy moving and old stocks such as instruments and equipment (Domingo, 2015). In addition to occupying spaces, it also consumes financial sources. It creates a cost to production for the usage of human power, facility, and extra equipment (dos Santos et al., 2017).

Unnecessary or excess inventory waste is generally because of the shortage of planning and failure to pair buying by the real spending and use the ratio of specific sources (Domingo, 2015).

Inventory is expressed as storage of datum and tools in a firm, as a job among operations, as an ingredient, knowledge, and design alternatives in deliverability. Accordingly, unnecessary or excess inventory waste is divided into three subcategories. These are ‘in the inventory of goods’, ‘in the inventory of operations’, and ‘in the inventory of the firm’ (Pessôa, 2008). As a benefit of unnecessary or excess inventory waste, less inventory is kept, and firms have the right to use their facility areas more effectively. Since less inventory is kept, there is also less packing and raw material consumption in products. Wastes can also eliminate due to aging and inexplicable errors (Hallam and Contreras, 2016).

2.5.4.7. Waste of Defects

Defect waste is completed products and services that do not fit client’s needs and procedures, also cause defective products to appear and result in client discontent (Hicks, 2007; Hidayati and Shalihin, 2020). This waste is NVA activities originating from dissimilar causes. For example, bad work piece quality that is unsatisfying to clients arises due to causes such as lesser condensation of workers on their work, bad control of operations, and quality of the bad vehicle (Chahal and Narwal, 2017). This occurs in lesser efficient operations for reprocessing, excessive audit work, and client grievances (Hidayati and Shalihin, 2020).

In these researches, defect waste generally occurs through reprocessing and junk (Womack and Jones, 2003; Wahab et al., 2013; Domingo, 2015; Sheikh Sha Alam et al., 2019). Inner defect waste, lag, reprocessing, and junk. Exterior defect waste, maintenance, guarantee, and area serving. These defect wastes cause an increase in costs in the lengthy-term and instantaneously. Also, a flaw in the TPS offers an offer for improvement rather than exchange (Wahab et al., 2013). Increasing costs include rechecking and planning of inventory, lack of capacity, and quarantine of inventory. In most firms, total defect costs make up an important percent of total production costs. Thanks to worker participation and Continuous Process Improvement (CPI), there is a great chance to decrease flaws in most plants (Sheikh Sha Alam et al., 2019).

Defect waste occurs due to product quality issues and increased delivery time and extreme in document works (Soltan and Mostafa, 2015; dos Santos et al., 2017; Prasad et al., 2018; Al Mouzani and Bouami, 2019). Production waste arises where intermediate storage is required and semi-finished products are available. In addition, in this case, production defects ie faulty wastes occur. The way to reduce this is to give education to workers that will enable them to control the job, product, and situations. A worker completing a division of labor must take direct control or a worker who manufactures a specific piece must have the right to control how that piece is manufactured (Kadam et al., 2012).

The called secret factory is a fine known topic of debate for anyone dealing with Six Sigma, TQM, and only ISO 9001 certification. When products and services do not meet the needs determined by the clients or the firm oneself, noncompliance with the concerned Costs of Poor Quality (COPQ) is divided as avoiding and evaluation costs and inner and exterior defect.

Avoiding and evaluation costs in the COPQ are the non-beneficial costs that a firm has and reduce value. For instance, the cost of inspecting goods from a supplier, in fact, indicates that the supplier’s job is doing bad quality. Inner defects and costs are caused by the wastes that constitute the seven kinds of main wastes of lean philosophy. Exterior defect costs are as follows. Administration of grievances and restituted product; The sacrifice of client income; Punishments to unsuitability; Reprocessing, recombining, choosing, and re-controlling product from clients; Administration of product in guarantee; and Lawful activities (Chiarini, 2013).

Defect elements must be recycled and disposed of (Fercoq et al., 2016). When a defect happens in the process, the production must be rescheduled and the product reworked. This situation causes an increase in costs (Kučerová et al., 2015). The reprocessing of defect products also causes waste of sources, loss of energy and raw materials, (Hallam and Contreras, 2016) and loss of clients (Al Mouzani and Bouami, 2019). At the same time, these wastes stop production. It is thrown away while tussling with client grievances and damages another equipment (dos Santos et al., 2017).

There are many causes for defect waste to occur. Some of these are usually associated with: Inadequate operations; Uncertain client features; Unqualified staff;

Deficiency of operation check; Inadequate suppliers; Partial quality rather than aggregate quality (Chiarini, 2013); Ability deficiency; Insufficient education; Extreme stock; and Operator mistake (Arunagiri and Gnanavelbabu, 2016). Also, once more the best dense causes of defects are become classified inside the ‘4M’. These are as follows. Bad work methods, bad instruction, and systems; Materials and goods; Insufficient machines and tools; and Unannounced and unskilled manpower (Chiarini, 2013). Therefore, removing these defects wastes would become made as follows: Creating defect preventing and Poka-Yoke; Raising personnel aware and education about quality and crucial features; Arranging instruction and processes; Creating devices to determining defects (for example, autonomation and Jidoka); Reviewing the check planing; Analysis of protective of the probability of defects (for example, Failure Mode and Effects Analysis (FMEA), Fault Tree Analysis (FTA) (Chiarini, 2013).

The concept of quality is to do the right thing the first time. This concept is about avoiding and organizing. This should not be understood as checking and correction. Defects and poor quality do not only mean a negative impact on corporate image and client dissatisfaction. Waste occurs because of extra prices and prolonged use for reprocessing, recycling, replacement, and repairing of defective products. It is the best efficient approach to reduce defect wastage by applying protective measures and using constant healing techniques (Domingo, 2015).

Defects refer to the formation of defective throughput in a development operation. Defect wastes are divided into ‘missing physical deliveries’ and ‘missing knowledge’ or knowledge not up-to-date during the operations (this also named ‘old deliveries’) (Pessôa, 2008). As a benefit of defect waste, if product defects are reduced, it will equate to the use of lesser energy and raw materials for these firms (Hallam and Contreras, 2016).

2.5.4.8. Waste of Underutilization of Employee or People Creativity

Further, the eighth waste in additionally these seven lean wastes was described by Womack and Jones (1996) and this waste has argued by other authors that the seven lean wastes are inherent. The name of this type of waste is the underutilization of employees or people and is related to their opinions and creativity to improve operations (Hicks, 2007). Waste always has a relationship with lean philosophy. Subsequently, all eight wastes entered Ohno's original list of waste as individuals or employees who were not sufficiently utilized by other authors (Wahab et al., 2013). The name of this waste is named differently in some sources. In general, this kind of waste called the waste of unused employee creativity or the underutilized people waste. The waste of unused employee creativity and talent is the waste generated by showing the existing knowledge, skills, and experiences of the employees and workforce incomplete and not using them in the related fields. This may become because of the wrong methods used in recruitment and bad administration (Soltan and Mostafa, 2015). The underutilized people waste occurs when irregular work, inefficient use of a potential person or employee's talent, not being given the correct job, not distributing the jobs equally, and the loss of opinions, abilities, and opportunities for improvement that emerge when businesses do not listen to their employees (Goodson, 2002; Ohno and Paridudin, 2010; Wahab et al., 2013) and the inability of employees to show their skills (Antony et al., 2015). If there are inefficient management and deterrent programs, it is the inability of employees to use their knowledge, skills, creativity, and innovative features (Prasad et al., 2018). This type of waste occurs when a firm is not reaping a high utility from its employees, has not been able to use its workforce effectively, and has not given a job on employees (Al Mouzani and Bouami, 2019).

The Waste Management is explained in detail in Chapter 2. The definition of the concept of waste and value, the actions that are part of the concept of waste and value, that VA, NNVA and NVA activities, obvious, less obvious waste and buffer waste, waste elimination, waste types, and seven lean wastes of lean production are explained. Methodology will be explained in the next section.

CHAPTER 3
METHODOLOGY

3.1. Research Framework

Two methods were used in this thesis. The first method used is the Waste Relationship Matrix (WRM). The purpose of this method is to express waste relationships in order to show the effect of a waste type on the other types of waste and affection wastes from other types of waste. WRM was used to measure and evaluate them. It was aimed to use lean tools to reduce and eliminate waste. So, the second method used is the Best-Worst Method (BWM). In BWM, compared to other Multi-Criteria Decision Making (MCDM) methods, binary comparisons are different. The purpose for this method is to obtain more consistent binary comparisons that yield more reliable results by first determining the best and worst criteria, and then comparing these criteria with all other criteria, without making binary comparisons between the criteria. Later, according to the results obtained with WRM, according to the results obtained with the ranking of the wastes that occurred and the results obtained with BWM, the ranking of the criteria weights will emerge, and lean production tools corresponding to each lean waste will emerge. As a result, a relationship will be established between lean wastes and lean production tools. For these two methods, a focus group was formed with ten experts from a firm that produces poultry products in the food firm, and it was aimed to use lean production tools to reduce and eliminate the lean waste and these wastes in this food firm in the production sector.

3.2 Waste Relationship Matrix (WRM)

The aim of lean production is to eliminate actions and waste that do not add value to a production process. In lean production, waste types, also known as ‘Muda’, emerge as seven types of lean waste. Lean seven wastes are overproduction, waiting, unnecessary or excess motion, transportation, overprocessing or excess processing, unnecessary or excess inventory and defect**.** Seven types of waste have the characteristic of being linked within themselves, and each type of waste has an effect and relationship with each other on the other types of wastes. For instance, waste of overproduction is the most dangerous type of waste between other wastes. Because it leads to the emergence of other types of waste (Kobayashi, 1995). Wu (2003) stated that overproduction will lead to changes in the workforce in factories, creating standardization difficult and creating quality-related issues. Other wastes also have distinctive features such as overproduction waste. However, the relationship of wastes with each other seems complicated. As seen on Figure 3.1, shown which waste effect and is affection by other waste.

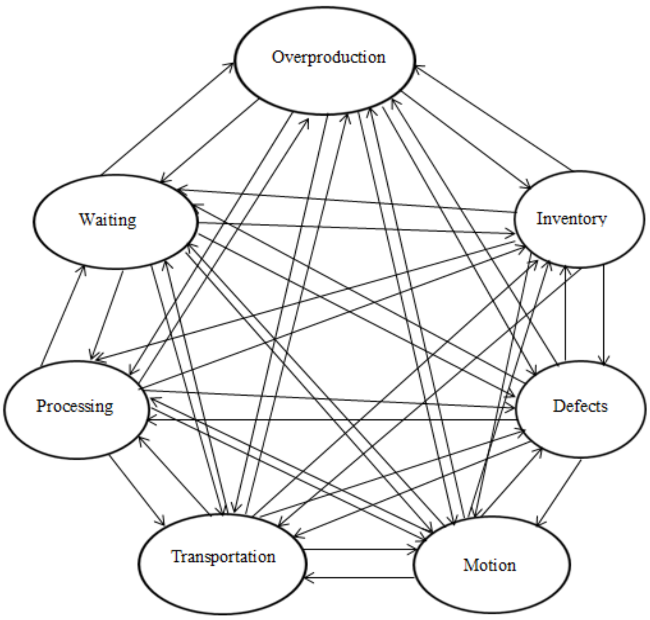

Figure 3.1. Relationship of Wastes

Therefore, the WRM provides a clearer overview of the complexity of the relationship between wastes, revealing the effect and relationship of one type of waste on the other types of wastes, and how they effect and affection each other. The detailed explanation of the WRM method is below.

Rawabdeh (2005) went down in history as the first person to identify the relationship between dissimilar types of waste and to use the notion of WRM. The purpose of this matrix is to build a connection between whole the dissimilar types of waste that arise in the production process. If the relationship of waste with other wastes has a strong and direct connection, this is seen as a possible source of actions that do not add value. Then, in order to improve this situation, ways of reducing and eliminating wastes are found by using lean production tools (Ali et al., 2015).

According to Rawabdeh (2005), in the WRM, every line expresses the effect of a particular waste type on the other types of waste. It expresses to what extent every column, a particular type of waste will become influenced by other types of waste. The diagonal section of the matrix is assigned the maximum relation value (ie relationship A assigned- the meaning of a carries the value 10.) Since every type of waste will have a final relationship with it. The WRM signifies true relations between wastes. WRM is utilized to describe the waste or wastes that have the most effect on whole other waste, and eliminating these wastes not just decreases other types of waste but also provides rapid healing in productivity.

3.2.1. Steps of WRM

Below, the application steps of the WRM are explained respectively.

Step 1: A description of the relationship of each waste to the other six wastes was made. For each type of waste, the first letter of the waste (O: Overproduction, I: Inventory, D: Defect, M: Motion, P: Processing, T: Transportation, W: Waiting) and the first letter of the other waste to be related. An underscore expression **(_)** is designated as an abbreviation, and definitions are made to reveal the relationship between these two wastes. This includes the same process for other wastes. Detailed descriptions of all waste relationships are as follows.

- Waste of Overproduction:

O_I: Although there is no demand from clients, overproduction wastes cause excessive production of products and piling these products in warehouses, thus unnecessary and excess inventories are created and unnecessary inventories are used to meet existing client orders.

O_D: Due to the overproduction, there is an extra increase in the working time of the workers and accordingly, both the defective production of the products and the defects, unskilled, skill deficiencies or insufficiency of the workers and operatives occur.

O_M: Overproduction wastes cause an irregular workplace due to a bad ergonomic structure and overproduction, and consequently the use of workers or equipment that move too much, walking, that is, showing excessive body motion.

O_T: Overproduction wastes lead to more transporting of materials or products from one station to another or from one warehouse to another in case of overproduction of products.

O_W: Due to overproduction, more work is carried out in a production process and there are waiting until the previous process is passed to the next process, and with the overproduction of the products, the products waiting in the warehouses become worn or damaged, and the waste increases, and in this case, when there is demand from clients they will have to wait as these products will not meet their expectations.

O_P: Overproduced products are produced very quickly and employees are directed to overproduction in order to compensate for the large and inelastic machine investment in excess processing or overprocessing waste.

- Waste of Unnecessary or Excess Inventory:

I_O: Increasing inventories cause unnecessary inventory and waste due to the production of excessive products and their storage, resulting in high costs and inefficiency in the food industry.

I_D: Keeping a high inventory level in warehouses causes an increase in waste, as well as making mistakes in the work of the employees, and making the processes and audits wrong and bad.

I_M: Moving a high level of inventory to warehouses causes increased movement of workers by walking or lifting them, and in poor and irregular storage areas, these movements increase further and reduce productivity.

I_T: High inventory levels, moving these inventories from one warehouse to another, or go and return between warehouses and blocking existing aisles cause a production activity to have a higher transportation time and cost.

I_W: Along with the storage of unnecessary inventories, it leads to waiting in the warehouses for these products.

I_P: The storage of unnecessary inventories is the creation of waste by further processing of products that are unwanted by clients and beyond their needs.

- Waste of Defects:

D_O: An overproduction attitude emerges to overcome the deficiency of materials or parts due to defects.

D_I: The production of defective parts that need to be reprocessed means that there are increased WIP levels in inventory form and if operatives make an error with the product, inadequacy and waste associated with checks of excess inventory levels occur.

D_M: It occurs by restricting the body movements of the employees in connection with the production of a defective product, having a bad job, and settlement arrangement.

D_T: If defective parts or products are produced, moving them to rework stations or from one process to another, from one warehouse to another, increases transport activity waste.

D_W: When defective products are sent to stations for reprocessing, if not processed, a waiting occurs and thus other defective products enter the queue, increasing the waiting time.

D_P: Overprocessing or excess processing defective products cause further increases in waste. In addition, if the working techniques and work processes used in a process are very flexible, if the processes do not flow according to a certain standard, the number of defective products increases, and thus processing waste occurs.

- Waste of Unnecessary or Excess Motion:

M_O: Making unnecessary or excess motion of the employees, they keep them from a certain amount of products they need to make or produce, causing more overproduction and waste.

M_I: Unnecessary or excess motion wastes appear as areas occupied by employees or equipment, due to excess inventories or high reprocessing rates.

M_D: Employees who move, walk or lift excessively in a production process get tired, show lower productivity, provide an inefficient flow of goods, and produce faulty products and waste.

M_T: The fact that employees do their jobs by making unnecessary or excess motion further increases their transportation activities and wastes.

M_W: Unnecessary or excess motion of the employees, removing them from the actual product that needs to be processed, and doing other jobs because these products to wait and turn into waste.

M_P: The reduction of unnecessary or excess motion of the employees in the processes can be realized by the firm's continuing the production processes by using small and flexible machines, not by using large and inflexible machines to show that there is a strong relationship between the machine and the employees.

- Waste of Transportation:

T_O: While the products are transported from one warehouse to another warehouse or from one place to another, the waste generated as a result of unnecessary movements between the processes increases the effort, energy, time, and costs due to the transportation of many products resulting from overproduction.

T_I: The transportation of products from one warehouse to another warehouse or from one place to another causes more transportation activity and the increase of wastes due to unnecessary or excess inventory in the warehouses.

T_D: While the products are transported from one warehouse to another warehouse or from one place to another, faulty products are also transported and quality problems and wastes related to the product arise.

T_M: Unnecessary or excess motion during the transportation of products from one warehouse to another warehouse or from one place to another - that is, by body movements such as walking, lifting, carrying while the employees do their work - causes waste to be formed.

T_W: If the product has not been processed, it does not move in a production process and within the factory and expects to move from one warehouse to another or from one place to another. If it is a finished product, it is then carried out waiting for the previous products to be transported. These cause the formation of waste.

T_P: With the presence and increase of excessive transportation activities, it ensures the production of more products and the creation of wastes by making more processing due to the prevention of the use of large and inflexible machines.

- Waste of Overprocessing or Excess Processing:

P_O: When a worker in a production process sends the product to another worker for the next process, if that worker is not ready to process the product, products accumulate and overproduction occurs in the WIP, and when the next worker checks this situation, the worker has many products to be processed and overprocessing or excess processing waste occurs.

P_I: Unwanted by the client, and by not meeting the client and product needs, further overprocessing or excess processing of the product is carried out, and unnecessary inventory waste caused by the storage of excess transaction inventories in WIP.

P_D: Overprocessing or excess processing waste can be reduced by the use of small and flexible machines with a certain quality, but if the machines are not maintained and controlled, the production of faulty products and waste will occur.

P_M: In overprocessing or excess processing , when a food firm chooses large and inflexible machines for their production instead of small and flexible machines, it causes the body movements of the employees to be unnecessary or excessive, causing the waste to be generated and both tires them and causes long delivery times.

P_T: Transporting the products that are overprocessed or to be processed from one warehouse to another or from one place to another causes waste, time, and costs to increase.

P_W: When an imbalance occurs in the production schedule, and there are times when workers and machines are idle or not working, there is waiting and waste for the product.

- Waste of Waiting:

W_O: A worker who is responsible for a machine leaves the front of the machine to carry out other activities, and this generates waiting, and due to the fact that this machine does not stay idle but only works for work, it is forced into overproduction

W_I: Waiting waste arises as unnecessary and excess inventory stack and waste of products that do not contain orders in WIP or warehouses.

W_D: Waiting products cause defective products to appear due to improper conditions, for example, wear, obsolescence, or damage to the product due to waiting.

W_M: In order to realize the next process, it increases the workers waiting for the product or material from the previous process to turn to other activities at that time and make unnecessary or excess motion.

W_T: Reductions in transport activities occur when products are not moving within a facility when workers and machines wait for an operation to finish, or wait for the next action.

W_P: Products are waiting when not processed, and the use of small and flexible machines should be increased to reduce waiting and prevent overprocessing or excess processing waste.

The abbreviations made in the definitions of waste relationships are explained below.

- The relationship of overproduction waste to other types of waste:

O_I: It refers to the effect of overproduction waste on unnecessary or excess inventory waste.

O_D: It refers to the effect of overproduction waste on defect waste.

O_M: It refers to the effect of overproduction waste on unnecessary or excess motion waste.

O_T: It refers to the effect of overproduction waste on transportation waste.

O_W: It refers to the effect of overproduction waste on waiting waste.

O_P: It refers to the effect of overproduction waste on overprocessing or excess processing waste.

- The relationship of unnecessary or excess inventory waste to other types of waste:

I_O: It refers to the effect of unnecessary or excess inventory waste on overproduction waste.

I_D: It refers to the effect of unnecessary or excess inventory waste on defect waste.
I_M: It refers to the effect of unnecessary or excess inventory waste on unnecessary or excess motion waste.

I_T: It refers to the effect of unnecessary or excess inventory waste on transportation waste.

I_W: It refers to the effect of unnecessary or excess inventory waste on waiting waste.

I_P: It refers to the effect of unnecessary or excess inventory waste on overprocessing or excess processing waste.

- The relationship of defect waste to other types of waste:

D_O: It refers to the effect of defect waste on overproduction waste.

D_I: It refers to the effect of defect waste on unnecessary or excess inventory waste.

D_M: It refers to the effect of defect waste on unnecessary or excess motion waste.

D_T: It refers to the effect of defect waste on transportation waste.

D_W: It refers to the effect of defect waste on waiting waste.

D_P: It refers to the effect of defect waste on overprocessing or excess processing waste.

- The relationship of unnecessary or excess motion waste to other types of waste:

M_O: It refers to the effect of unnecessary or excess motion waste on overproduction waste.

M_I: It refers to the effect of unnecessary or excess motion waste on unnecessary or excess inventory waste.

M_D: It refers to the effect of unnecessary or excess motion waste on defect waste.

M_T: It refers to the effect of unnecessary or excess motion waste on transportation waste.

M_W: It refers to the effect of unnecessary or excess motion waste on waiting waste.

M_P: It refers to the effect of unnecessary or excess motion waste on overprocessing or excess processing waste.

- The relationship of transportation waste to other types of waste:

T_O: It refers to the effect of transportation waste on overproduction waste.

T_I: It refers to the effect of transportation waste on unnecessary or excess inventory waste.

T_D: It refers to the effect of transportation waste on defect waste.

T_M: It refers to the effect of transportation waste on unnecessary or excess motion waste.

T_W: It refers to the effect of transportation waste on waiting waste.

T_P: It refers to the effect of transportation waste on overprocessing or excess processing waste.

- The relationship of overprocessing or excess processing waste to other types of waste:

P_O: It refers to the effect of overprocessing or excess processing waste on overproduction waste.

P_I: It refers to the effect of overprocessing or excess processing waste on unnecessary or excess inventory waste.

P_D: It refers to the effect of overprocessing or excess processing waste on defect waste.

P_M: It refers to the effect of overprocessing or excess processing waste on unnecessary or excess motion waste.

P_T: It refers to the effect of overprocessing or excess processing waste on transportation waste.

P_W: It refers to the effect of overprocessing or excess processing waste on waiting waste.

- The relationship of waiting waste to other types of waste:

W_O: It refers to the effect of waiting waste on overproduction waste.

W_I: It refers to the effect of waiting waste on unnecessary or excess inventory waste.

W_D: It refers to the effect of waiting waste on defect waste.

W_M: It refers to the effect of waiting waste on unnecessary or excess motion waste.

W_T: It refers to the effect of waiting waste on transportation waste.

W_P: It refers to the effect of waiting waste on overprocessing or excess processing waste.

Step 2: A questionnaire-based measurement criterion has been developed to measure and evaluate the relationship between wastes. This questionnaire consists of 6 questions (Rawabdeh, 2005) and the answer to each question has a weight between 0 and 4. Because of the different relationships and effects and affection of wastes with each other, these relationships are not of the same weight. The need to give weight is due to the purpose of showing which types of waste that are or may be generated in food firm is more effective in this waste generation process. These weights are written opposite each answer. This is shown in Appendix 1. In addition, questionnaire questions with demographic characteristics were prepared for the people who filled this questionnaire. These questionnaire questions are shown in Appendix 2.

Step 3: According to each waste relationship, the questionnaire questions were answered and data were obtained according to the weight of the answers to the questions (each answer had a weight between 0 and 4). These data express the effect and affection of a waste type on other types of waste. With the sum of weights of each answer were written and the results have been added to the 'Score' column.

Step 4: To assess the strengths of the waste relationships, the score range was made between 1 and 20 and divided into five equivalent spacing, every showing the strength grade of relation. Score ranges are as seen on Table 3.1.

Table 3.1. Range Parts of Strength of Waste Relationships

Range	Type of Relationship	Symbol Letter
17 to 20	Absolutely necessary	A
13 to 16	Especially important	E
9 to 12	Important	I
5 to 8	Ordinary closeness	O
1 to 4	Unimportant	U

Step 5: There are symbol letters corresponding to these total scores, and each of these symbol letters has a value. Symbol letters corresponding to each total score were written and added to the 'Relationship' column. These values also formed the Waste Matrix Value. Waste Matrix Values are as seen on Table 3.2.

Table 3.2. Waste Matrix Values

Symbol Letter	Value
A	10
E	8
I	6
O	4
U	2
X	0

Step 6: After the Waste Matrix Values are entered into the matrix according to each waste relationship, the sum of these values is taken as rows and columns and percentage values are calculated for simpler measurement. Also, the sum of the rows and columns and the percentage calculations should be equal.

3.3. Best-Worst Method (BWM)

In daily life, people encounter problems and strive to find and analyze the most suitable solution for this (Pamučar et al., 2020). Decision making represents an important role in job actions in today's world (Sadjadi and Karimi, 2018). The decision-making process and selection of the best alternative are based on the analysis of multiple criteria and a set of constraints (Pamučar et al., 2020). Various criteria come into question in this decision-making and selection process. Therefore, its problems are analyzed with MCDM (Zavadskas ve Turskis, 2010). More generally, MCDM has arisen to obtain the optimum solution for the purpose of the decision problem. The necessary steps to reach this optimum solution are determining the most suitable alternative, sorting and grouping these alternatives on the basis of criteria, and creating a solution sequence among suitable alternatives (Aslan, 2017). The most important point of the MCDM problem is the ordering of these alternatives using logical preferences and certain mathematical tools. The MCDM is an important part of administration and systems engineering science and contemporary decision-making science, which is widely implemented in several fields - namely, economics, medicine, engineering, administration, military, and logistics (Diyaley and Chakraborty, 2019; Hassanpour, 2019).

Best-Worst Method (BWM) is an MCDM method developed by Jafar Rezaei (Delft University of Technology) in 2015. BMW is a new MCDM method compared to other methods (Rezaei,2015; Rezaei, 2016). BWM is an MCDM method that can become utilized in various stages to solve an MCDM problem. BWM can be utilized to assess alternatives against criteria and to discover the significance (weight) of the criteria utilized to discover a solution to achieve the principal purposes of the problem. This method can become utilized by a decision-maker (DM) or a group of DM (Rezaei, 2020). In 2015, Rezaei (2015) presented BWM is new that makes the least binary comparisons between criteria and trustworthy outcomes. In this method, the DM is responsible for determining the best and worst criteria. The best determined criterion has the most significant role in decision making. The worst determined criterion has the opposite role (Rezaei, 2015).

BWM is a comparison-based MCDM method that compares the best determined criterion with other criteria and compares all other criteria with the worst determined criterion. Thanks to this method, DM do not need to make binary comparisons between all criteria. Only the most and least desirable criteria are determined and then paired comparisons are made between the best and worst criteria and the other criteria. A Consistency Ratio is used to control the reliability of the method. In addition, it brings a structure to the problem by first determining the best and worst criteria and then comparing these two criteria with whole other criteria. This enables the DM to obtain reliable results in binary comparisons (Rezaei, 2015). BWM only gives rise to two vectors including integers. This avoids a basic problem connected with the usage of fractions in binary comparisons (Salo and Hämäläinen, 1997). In BWM, a minimum and maximum mathematical programming model was created in order to define the optimal weights of different criteria, taking into account the binary comparisons (Safarzadeh et al., 2018).

In the last 5 years, BWM has been used in many real-world MCDM problems. The areas where this method is used are areas like supply chain management, energy, business and economics, education, production, transportation, airline industry, health, investment, communication, banking, performance evaluation, tourism, engineering and technology. In addition, there are many studies using just the BWM method (single integration), and articles using this method jointly by other methods (multiple integrations) (Pamučar et al., 2020; Rezaei, 2020). BWM is developed by

Rezaei (2015), has been successfully implemented by many researchers such as Rezaei et al. (2015); Sadaghiani et al. (2015); Gupta and Barua (2016); Mou et al. (2016); Rezaei et al. (2016); Salimi and Rezaei (2016); Ahmad et al. (2017); Ahmadi et al. (2017); Gou and Zhao (2017); Ren et al. (2017); and Gupta (2018).

3.3.1. Steps of BWM

Below, the application steps of the BWM are explained respectively (Rezaei, 2015).

Step 1: A number of decision criteria are set. In this step, the DM determines the n criteria $C= \{c_1, c_2, ..., c_n\}$ used to give the decision. n denotes the total number of the criteria.

Step 2: The best (c_b) and worst (c_w) criteria are determined by the DM from the set of criteria. The criterion determined as the best is the most desired and most significant criterion. The worst criterion is the least desired and least significant criterion.

Step 3: The preference ratio of the criterion that is best (c_b) chosen according to all other criteria is determined for binary comparison. This preference ratio is expressed by the DM as a number between 1 and 9 where 1 is 'equally significant' and 9 is 'extremely significant'. The number between 1 and 9 is to determine the best criterion to be preferred over all other criteria. Then a vector called 'Best-to-Others' (A_B) is reached that goes from best to others. This vector is as follows.

$$A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn}) \tag{1}$$

Each a_{Bj} in the A_B vector shows the preference of B, which is the best criterion, according to criterion j. Value is an integer number between 1 to 9. In addition, a_{BB} = 1. This means that the most desired and most significant criterion will be compared with itself.

Step 4: The preference ratio of the criterion that is worst (c_w) chosen according to all other criteria is determined for binary comparison. This preference ratio is expressed by the DM as a number between 1 and 9 as in step 3. With the determined number between 1 and 9, the importance of all other criteria on the worst criterion is determined. As a result, the vector emerges which is the worst from the other criteria. Then a vector called 'Others-to-Worst' (A_W). This vector is as follows.

$$A_W = (a_{1W}, a_{2W}, \ldots, a_{nW})^T \tag{2}$$

Each a_{jW} in the A_W vector, shows the preference of criterion j over the worst criterion W. In addition, $a_{WW} = 1$. This means that the worst criterion will be compared to itself.

Step 5: For each criterion, their optimal weight is determined $w^* = (w_1^*, w_2^*, \ldots, w_n^*)$. In this step, the purpose is to determine the optimal weights of the criteria so as to provide the maximum absolute differences. The optimal weight for the criteria is $w_B / w_j = a_{Bj}$ and $w_j / w_w = a_{jw}$ for each pair of w_B / w_j and w_j / w_w, respectively ($j = 1, 2, \ldots, n$). So, to provide these circumstances for whole j, necessary to obtain a solution where the maximum absolute differences $|w_B/w_j - a_{Bj}|$ and $|w_j/w_W - a_{jW}|$ must become minimized. Also, the weight vector must not be negative and the total condition must be 1. As a result, the following problem arises.

$$\min_{w} \max_{j} \{|w_B/w_j - a_{Bj}|, |w_j/w_W - a_{jW}|\}$$

$$\sum_{j=1}^{n} w_j = 1, \qquad w_j \geq 0, \text{ for whole } j = 1, 2, \ldots, n \tag{3}$$

The problem equation is transferred to the following linear programming problem.

$$\min \xi$$

$$|w_B/w_j - a_{Bj}| \leq \xi, \text{ for whole } j$$

$$|w_j/w_W - a_{jW}| \leq \xi, \text{ for whole } j$$

$$\sum_{j=1}^{n} w_j = 1, \qquad w_j \geq 0, \text{ for whole } j = 1, 2, \ldots, n \tag{4}$$

Step 6: With the completion and solving of all this model, optimum weights (w_1^* ,w_2^* , ..., w_n *) and ξ value are obtained. The value of ξ expresses the maximum absolute difference and the Consistency Ratio (CR) of the analyzes made. The CR is used to control the reliability of the optimal weights and it expresses the reliability among the got weights and the binary comparison datums ensured by the DM. CR is shown as follows.

$$\text{CR} = \xi^{*} / \textit{Consistency Index (CI)} \tag{5}$$

CR is a number between 0 and 1 (CR ∈ [0, 1]). 0 indicates complete consistency. ξ indicates the maximum absolute difference found from Model 4. According to the c_w criterion, determining the largest a_{BW} preference ratio of the c_b criterion (1,2, ..., 9), the maximum ξ value emerges. These maximum values are used as CI. It turned out that the higher the value, the weaker their CR and the less reliable the comparisons, and the lower the value, the higher the CR and higher reliable the comparisons.

The methodology explained in detail in Chapter 3. The methods of WRM and BWM and their steps are explained. Implementation of the study will be explained in the next section.

CHAPTER 4

IMPLEMENTATION OF THE STUDY

4.1. Application Area of Research Method of WRM and BWM

For this thesis, a firm operating in the Food Sector, producing poultry products, was selected. Firstly, in Turkey, in general, the food sector and poultry products production, it has been researched.

4.1.1. Food Sector in Turkey

The concept of food is the most important and basic source of necessity in human life and it is of great importance when public health is considered. Thus, one of the most important issues of food production and consumption chain (Ankara Sanayi Odası – Muhtelif Gıda Sektörü, 2019). The food sector, because it has rich agricultural resources, has been one of the first established in Turkey’s economy and rapidly growing sector. Food, beverage, and agriculture sectors are intertwined with each other, always maintaining relationships and complementing each other. The food sector includes 280 billion pounds upcoming share in Gross Domestic Product (GDP), employees over 400 thousand, 2.2 million producers, including about 13.000 producer organizations on the ride, and small or large scale firms over 30 thousand, Turkey has become the largest production industry position (TÜSİAD, 2020). Turkey, in the food sector, with agricultural production and increasing population, the last 10 years, due to the increase in the average level of income has shown that production power. Food and Drink Industry Associations of Turkey Federation, for the year 2023, food and beverage export targets were targeted to be $ 40 billion. The food sector, which is considered as one of the sectors with the most important socio-economic impacts of today, includes many sub-branches. These sub-branches are Meat and Meat Products, Milk and Dairy Products, Flour and Bakery Products, Fruit and Vegetable Products, Fats and Oils, Sugar and Sugar Products, Soft Drinks, Alcoholic Beverages, Fermented Products, Ready-to-Eat Foods, and Baby Food can be counted (Ankara Sanayi Odası – Muhtelif Gıda Sektörü, 2019).

Turkey is one of the sectors with the largest share of foreign trade is one of the food industry. In the last 17 years, it has increased from $ 30 billion to $ 157 billion (Kırıkkale Ticaret ve Sanayi Odası- 2019 Gıda Sektör Raporu, 2019). According to the data obtained from TUIK, exports of 14.63 billion dollars and imports of 11.74 billion dollars were realized in the agriculture, food, and beverage sectors in 2020. Nuts, fresh fruit, sugar, and sugary products, vegetable oil, and dried fruits/vegetables are among the sectors that made the most exports in the 9 months of this year. 42.5 percent of total exports were realized by these five sectors. Animal feed, vegetable oil, flour, starch, and cocoa-chocolate were among the sectors that imported the most in this period. 64.8 percent of total imports were carried out by these 5 sectors. According to economic activities, the share of the production industry in exports in December 2020 was 93.2 percent and the share of consumption goods in imports was 12.1 percent. In December 2020, the production index increased by 27.32 percent year on year. Retail sales volume, food, beverage, and tobacco sales increased by 8.8 percent in December 2020 (TÜİK, 2021). In January 2021, according to the data, Turkey agriculture, the food, and beverage industry, annual exports $ 1.76 billion, and annual imports, $ 1.37 billion (Türkiye Gıda ve İçecek Sektörleri Dış Ticaret Verileri – TGDF, 2021).

4.1.2. Overview of the Poultry Sector

In today’s world, the chicken industry in Turkey has become an important sector, increase exports always and continues, in the same way, the growth, support of agriculture and by providing intensive employment significantly to the Turkish economy, has become one of the sectors that provide added value. Egg poultry is a very important breeding activity in terms of egg production, which is a basic food for human nutrition (Çiçekgil and Yazıcı, 2016).

Turkey, approximately, with 20 billion pieces of poultry production reached its highest level in 2019. 2019 has been an important year for poultry production. For the production of poultry; in 2019, the number of chickens, which reached 343 million pieces, constitutes 98.2 percent of poultry. When the regional distribution in poultry production is examined; it is seen that the Aegean Region is in the leading position with 33.3 percent in 2019. In addition, 34.6 percent are poultry products. Turkey, for poultry production, in terms of brood material is dependent on the external. Therefore, with the increase in poultry production and the need for breeding material, the breeding or hatching egg imports reached 1,920 tons in 2019 (Tarım Ürünleri Piyasaları, 2020). According to data obtained from TUIK, in Turkey, in December 2020, the poultry production totaled 1.7 billion units (TÜİK, 2021). In Turkey, in 2020, a total of 19 billion 788 million eggs were produced. The export amount of poultry in the January-November (11 months) period of 2020 has approached approximately 200 thousand tons. In the 11-month period of 2020, as the need for breeding material in poultry production has stabilized, the import of breeding or hatching eggs has decreased to 1,584 tons (Tarım Ürünleri Piyasaları, 2021). According to the data obtained from TUIK, poultry production in January 2021 was 1.7 billion units (TÜİK, 2021).

4.2. Data Analysis and Results

4.2.1. Data Collection

In this thesis, in the production processes of a firm in the food sector, the effects of the wastes within the scope of 'seven lean wastes' that occur, on each other, their effects, affection and relations were analyzed. In order to measure and evaluate the relationship of wastes with each other, a focus group was formed with ten experts operating in the a food firm, producing poultry. These experts were sent questions about the questionnaire-based measurement criteria developed, which must be answered in connection with both the definition of waste relationship. In order to obtain more detailed information about these ten experts, a questionnaire containing demographic characteristics was also sent. These are shown in Appendix 1 and 2.

Focus group is a group interview and qualitative data collection method with approximately 8-12 people, including people with similar demographic characteristics (for example, socio-economic level, and age group). The aim of the focus group is to obtain qualitative information about a specified topic, participant's experiences, perspectives, and opinions. The questions and expectations regarding the subject examined in the focus group are evaluated according to the experiences of the interviewees and the answers related to the subject are revealed (Şahin, 2009).

4.2.2. Questionnaire Respondents and Analysis

By conducting a questionnaire, including an expert focus group of ten, the answers to the questions asked about gender, age, education, experience, the operating time of the firm they work for, the number of employees of the firm, the department they work for, the lean production practices, and tools of the firm were analyzed. In line with the analysis; For the gender group, out of 10 people, 6 people are female and 4 people are male; For the age group, 4 people are in the age range of 20-29, 5 people in the age range of 30-39, 1 person in the age range of 40-49; For the educational status group, 9 people are undergraduate and 1 person is master's; For their experiences in the firm; 5 people with between 5 and 10 years of working experience; 1 person with between 11 and 15 years of working experience; 2 people between 16 and 20 years of working experience; 2 people have over 20 years of working experience. The operating period of the firm is over 20 years; The total number of employees in the firm is in the range of 501-700 people; The department they work in, the lean systems department; Knows, adopts and applies lean production practices in its firms in the lean production applications group; They use Visual Management System, Hoshin Kanri, Kaizen, 5S, TPM, SMED, and Poke-Yoke among lean production tools in their firms, the answers were obtained.

4.3. Results of Research Method of WRM

The WRM was utilized to determine the most significant and risky type of waste in the food sector. This method was done in a high-capacity production environment to discover waste that had to become removed from a production process.

The WRM method was applied to measure and evaluate the relationship of wastes with each other and their effect on each other. As seen on Table 4.1, contained the answers from ten experts in the food sector, working in the Lean Systems Department, who operate in a facility producing poultry products. Also, in this table, total scores were obtained according to the weight of their answers to each question (each answer had a weight between 0 and 4) and written in the 'Score' (S) the column. Symbol letters corresponding to these scores were written in the 'Relationship' (R) the column.

Table 4.1. Answers of Relationships of Wastes

Questions	1		2		3		4		5		6			
Relationship of Waste	**A**	**W**	**A**	**W**	**A**	**W**	**A**	**W**	**A**	**W**	**A**	**W**	**S**	**R**
O_I	a	4	a	2	a	4	a	2	b	1	a	4	17	A
O_D	a	4	b	1	b	2	a	2	ı	4	a	4	17	A
O_M	a	4	a	2	a	4	a	2	d	1	b	2	15	E
O_T	a	4	a	2	a	4	a	2	e	2	a	4	18	A
O_W	a	4	a	2	b	2	a	2	ı	4	a	4	18	A
O_P	a	4	b	1	a	4	a	2	e	2	b	2	15	E
I_O	b	2	b	1	c	0	a	2	b	1	c	0	6	O
I_D	a	4	b	1	a	4	a	2	ı	4	a	4	19	A
I_M	a	4	a	2	a	4	a	2	g	2	b	2	16	E
I_T	a	4	b	1	a	4	a	2	d	1	a	4	16	E
I_W	c	0	a	2	c	0	a	2	c	1	c	0	5	O
I_P	c	0	b	1	c	0	a	2	b	1	c	0	4	U
D_O	a	4	a	2	a	4	a	2	ı	4	a	4	20	A
D_I	a	4	a	2	a	4	a	2	ı	4	a	4	20	A
D_M	a	4	a	2	a	4	a	2	b	1	a	4	17	A
D_T	a	4	a	2	a	4	a	2	c	1	a	4	17	A

D_W	b	2	b	1	b	2	a	2	g	2	b	2	11	I
D_P	a	4	b	1	a	4	a	2	a	1	a	4	16	E
M_O	c	0	b	1	c	0	a	2	b	1	a	4	8	O
M_I	c	0	c	0	c	0	b	1	d	1	c	0	2	U
M_D	b	2	a	2	b	2	a	2	e	2	b	2	12	I
M_T	c	0	a	2	b	2	a	2	c	1	b	2	9	I
M_W	b	2	a	2	c	0	a	2	d	1	b	2	9	I
M_P	c	0	a	2	c	0	2	a	b	1	c	0	5	O
T_O	b	2	b	1	a	4	a	2	d	1	c	0	10	I
T_I	c	0	c	0	c	0	a	2	e	2	c	0	4	U
T_D	a	4	b	1	a	4	a	2	e	2	a	4	17	A
T_M	a	4	b	1	a	4	a	2	d	1	a	4	16	E
T_W	b	2	b	1	b	2	a	2	c	1	b	2	10	I
T_P	c	0	c	0	c	0	a	2	e	2	c	0	4	U
P_O	b	2	a	2	b	2	a	2	b	1	a	4	13	E
P_I	b	2	a	2	b	2	c	0	d	1	b	2	9	O
P_D	c	0	b	1	c	0	a	2	ı	4	c	0	7	O
P_M	a	4	a	2	a	4	a	2	b	1	b	2	15	E
P_T	b	2	b	1	c	0	a	2	e	2	b	2	9	I
P_W	a	4	b	1	b	2	a	2	e	2	b	2	13	E
W_O	b	2	b	1	b	2	a	1	c	1	c	0	7	O
W_I	a	4	b	1	a	4	a	2	a	1	b	2	14	E

W_D	a	4	b	1	b	2	a	2	ı	4	b	2	15	E
W_M	b	2	b	1	b	2	a	2	c	1	b	2	10	I
W_T	a	4	c	0	b	2	a	2	d	1	b	2	11	I
W_P	b	2	c	0	c	0	a	2	g	2	b	2	8	O

A: Answer and **W:** Weight of Answer

With these symbol letters, the WRM was created. Since each waste will have an ultimate relation to itself, the maximum value, the letter A, is written. WRM is as seen on Figure 4.1.

F/T	**O**	**I**	**D**	**M**	**T**	**P**	**W**
O	**A**	A	A	E	A	E	A
I	O	**A**	A	E	E	U	O
D	A	A	**A**	A	A	E	I
M	O	U	I	**A**	I	O	I
T	I	U	A	E	**A**	U	I
P	E	O	I	E	I	**A**	E
W	O	E	I	I	I	O	**A**

Figure 4.1. Waste Relationship Matrix

Waste relationship values corresponding to these symbol letters were written. Sum of rows and columns, and percentages of total values were taken and written. Waste Matrix Value is as seen on Figure 4.2

F/T	O	I	D	M	T	P	W	S	Percent (%)
O	**10**	10	10	8	10	8	10	66	18.75
I	4	**10**	10	8	8	2	4	46	13.07
D	10	10	**10**	10	10	8	6	64	18.18
M	4	2	6	**10**	6	4	6	38	10.79
T	6	2	10	8	**10**	2	6	44	12.5
P	8	4	4	8	6	**10**	8	48	13.64
W	4	8	8	6	6	4	**10**	46	13.07
SCORE	46	46	58	58	56	38	50	**352**	**100**
Percent (%)	13.07	13.07	16.48		15.91	10.79	14.20	**100**	

Figure 4.2. Waste Matrix Value

4.3.1. Analysis of Results of WRM

The results obtained from the figure above are interpreted as follows. Interpretations are made according to the description of waste relationships. The results are primarily the effect of one type of waste on other types of waste in the food firm in question; later, it was interpreted as a waste type being affection by other types of waste. In the created WRM, it turned out that different waste relationships have a stronger relationship with higher scores, while lower scores have a weaker relationship.

Firstly, in the whole matrix, the highest, overproduction waste had an effect on other types of waste at 18.75 percent. In other words, the first waste that became generated the most in the production processes of the products of the food firm in question appears to be overproduction waste. Overproduction waste appears to be the most important type of waste, as it occurs when products are produced too much or too early, and together with the highest rate of 18.75 percent obtained from the matrix. Previously, in the literature review, it was stated that overproduction waste is the riskiest and the most important type of waste among other wastes, poses many problems, and causes the emergence of another type of waste. In other words, with this result, it is understood that the relationship and effect of overproduction waste with other wastes is compatible with the literature review. When the waste relationship values were examined, the following results emerged. When examining the effect of overproduction waste on other types of waste, the effect on unnecessary or excess inventory waste, defect waste, transportation waste, and waiting waste revealed a strong relationship. Although there is no demand from clients, overproduction wastes caused excessive production of products and piling these products in warehouses, thus unnecessary and excess inventories are created and unnecessary inventories are used to meet existing client orders. Due to the overproduction, there is an extra increase in the working hours of the workers and as a result, both the faulty production of the products and the defects of the workers and operators, unskilled, skill deficiencies or insufficiencies occurred. Overproduction wastes caused more transporting of materials or products from one station to another or from one warehouse to another in case of overproduction of products. Due to overproduction, more work was done in one production run and the previous process was expected to move on to the next, and with the overproduction of products, the products waiting in the warehouses were worn or damaged and the waste increased. In this case, they had to wait when there was a demand from clients because these products did not meet their expectations. The effect of overproduction waste on unnecessary or excess motion waste and overprocessing or excess processing waste revealed a very important relationship. Overproduction wastes caused an irregular workplace due to a bad ergonomic structure and overproduction, and consequently, the use of workers or equipment that move too much, walking, that is, showing excessive body motion. Overproduced products are produced very quickly and employees are directed to overproduction in order to compensate for the large and inelastic machine investment in overprocessing or excess processing waste. When the effects of other waste types on overproduction waste are examined, the following results have been obtained. The effect of defect waste on overproduction waste revealed a strong relationship. An overproduction attitude emerged to overcome the deficiency of materials or parts due to defects. The effect of overprocessing or excess processing waste on overproduction waste revealed a very important relationship. When a worker in a production process sends the product to another worker for the next process, if that worker is not ready to process the product, products accumulated and overproduction occurred in the WIP, and when the next worker checked this situation, the worker has many products to be processed and overprocessing or excess processing waste occurred. The effect of transportation waste on overproduction waste revealed an important relationship. While the products are transported from one warehouse to another warehouse or from one place to another, the waste generated as a result of unnecessary movements between the processes increased the costs due to the transportation of many products resulting from overproduction. The effect of unnecessary or excess inventory waste, unnecessary or excess motion waste and waiting waste on overproduction waste revealed a normal level of relationship. Increasing inventories caused unnecessary inventory and waste due to the production of excessive products and their storage, resulted in high costs and inefficiency in the food firm. Made unnecessary or excess motion of the employees, they kept them from a certain amount of products they need to made or produced, caused more overproduction and waste. A worker who is responsible for a machine left the front of the machine to carry out other activities, and this generated waiting, and due to the fact that this machine did not stay idle but only works for work, it is forced into overproduction. After examining all this, the effect of other wastes on overproduction waste, that is, overproduction waste was found to be affected by other types of waste, with a rate of 13.07 percent.

Secondly, in the matrix, the effect of defect waste on other waste emerged as the second highest waste after overproduction waste, with a rate of 18.18 percent. In other words, the second waste that occurred most frequently in the production processes of the products of the food firm in question appears to be defect waste. Defect waste arises when products that do not meet the needs of clients, are caused by employees, are produced incorrectly. When the waste relationship values were examined, the following results emerged. When the effect of defect waste on other types of waste was examined, the effect on overproduction waste, unnecessary or excess inventory waste, unnecessary or excess motion waste, and transportation waste revealed a strong relationship. An overproduction attitude emerged to overcome the deficiency of materials or parts due to defects. The production of defective parts that need to be reprocessed means that there are increased WIP levels in inventory form and if operatives make an error with the product, inadequacy and waste associated with checks of excess inventory levels occurred. It occurred by restricting the body movements of the employees in connection with the production of a defective product, had a bad job, and settlement arrangement. If defective parts or products are produced, moving them to rework stations or from one process to another, from one warehouse to another, increased transport activity waste. When the effects of other waste types on defect waste were examined, the following results were obtained. The effect of overproduction waste, unnecessary or excess inventory waste and transportation waste on defect waste revealed a strong relationship. Due to the overproduction, there is an extra increase in the working time of the workers and accordingly, both the defective production of the products and the defects, unskilled, skill deficiencies or insufficiency of the workers and operatives occurred. Kept a high inventory level in warehouses caused an increased in waste, as well as made mistakes in the work of the employees, and made the processes and audits wrong and bad. While the products are transported from one place to another, faulty products are also transported and quality problems and wastes related to the product arised. The effect of waiting waste on defect waste revealed a very important relationship. Waiting products caused defective products to appear due to improper conditions, for example, spoilage products or damage to the products due to waiting. The effect of unnecessary or excess motion waste on defect waste revealed an important relationship. Employees who move, walk or lift excessively in a production process get tired, showed lower productivity, provided an inefficient flow of goods, and produced faulty products and waste. The effect of overprocessing or excess processing waste on defect waste revealed a normal level of relationship. Overprocessing or excess processing waste can be reduced by the use of small and flexible machines with a certain quality, but if the machines are not maintained and controlled, the production of faulty products and waste occurred. After examining all this, the effect of other wastes on defect waste, that is, defect waste was found to be affected by other types of waste, with a rate of 16.48 percent. Thus, emerged as the most affected waste from other types of waste.

Thirdly, in the matrix, the effect of overprocessing or excess processing waste on other types of waste emerged with a rate of 13.64 percent. In other words, the third waste that occurred most frequently in the production processes of the products of the food firm in question appears to be overprocessing or excess processing waste. Overprocessing or excess processing waste arises more when the firm uses large and inflexible machines. When the waste relationship values were examined, the following results emerged. When the effect of overprocessing or excess processing waste on other types of waste is examined, its effect on overproduction waste, unnecessary or excess motion waste, and waiting waste revealed a very important relationship. When a worker in a production process sends the product to another worker for the next process, if that worker is not ready to process the product, products accumulated and overproduction occurred in the WIP, and when the next worker checked this situation, the worker has many products to be processed and overprocessing or excess processing waste occurred. When a food firm chosen large and inflexible machines for their production instead of small and flexible machines, it caused the body movements of the employees to be unnecessary or excessive, caused the waste to be generated and both tires them and caused long delivery times. When an imbalance occurred in the production schedule, and there are times when workers and machines are idle or not working, there is waiting and waste for the product. The effect of overprocessing or excess processing waste on transportation waste revealed an important relationship. Transporting the products that are overprocessed or to be processed from one warehouse to another or from one place to another caused waste to increased. The effect of overprocessing or excess processing waste on unnecessary or excess inventory waste and defect waste revealed a normal level of relationship. Unwanted by the client, and by not meeting the client and product needs, further overprocessing or excess processing of the product is carried out, and unnecessary inventory waste caused by the storage of excess transaction inventories in WIP. This waste type can be reduced by the used of small and flexible machines with a certain quality, but if the machines did not maintained and controlled, the production of faulty products and waste will occurred. When the effect of other waste types on overprocessing or excess processing waste was examined, the following results emerged. The effect of overproduction waste and defect waste on overprocessing or excess processing waste revealed a very important relationship. Overproduced products are produced very quickly and employees are directed to overproduction in order to compensate for the large and inelastic machine investment in overprocessing waste or excess processing. Kept a high inventory level in warehouses caused an increased in waste, as well as made mistakes in the work of the employees, and made the processes and audits wrong and bad. The effect of unnecessary or excess motion waste and waiting waste on overprocessing or excess processing revealed a normal level relationship. The reduction of unnecessary or excess motion of the employees in the processes became realized by the firm's continued the production processes by used small and flexible machines, not by use large and inflexible machines to show that there is a strong relationship between the machine and the employees. Products are waiting when not processed, and the used of small and flexible machines should be increased to reduce waiting and prevented overprocessing or excess processing waste. However, the effect of unnecessary or excess inventory waste and transportation waste on overprocessing or excess processing waste is not a important relationship, but revealed a weak relationship. After examining all this, the effect of other wastes on overprocessing or excess processing waste, that is, overprocessing or excess processing waste was found to be affected by other types of waste, with a rate of 10.79 percent. Thus, it emerged as the lowest percentage between wastes affected by other types of waste.

Fourthly, it turned out in the matrix that the effect of unnecessary or excess inventory waste and waiting waste on other types of waste emerged with a rate of 13.07 percent, was the same. In other words, the fourth waste that occurred most frequently in the production processes of the products of the food firm in question appears to be unnecessary or excess inventory waste. Unnecessary or excess inventory waste arises when products are piled into warehouses in the form of unnecessary or excess inventories. When the waste relationship values were examined, the following results emerged. When the effect of unnecessary or excess inventory waste on other waste is examined, the effect on defect waste revealed a strong relationship. Kept a high inventory level in warehouses caused an increased in waste, as well as made mistakes in the work of the employees, and made the processes and audits wrong and bad. The effect of unnecessary or excess inventory waste on unnessecary or excess motion waste and transportation waste revealed a very important relationship. Moving a high level of inventory to warehouses caused to increased movement of workers by walking or lifting them, and in poor and irregular storage areas, these movements increased further and reduced productivity. High inventory levels, moving these inventories from one warehouse to another, or go and return between warehouses and blocking existing aisles caused a production activity to have a higher transportation time and cost. The effect of unnecessary or excess inventory waste on overproduction waste and waiting waste revealed a normal level relationship. Increasing inventories caused unnecessary inventory and waste due to the production of excessive products and their storage, resulted in high costs and inefficiency in the food firm. Along with the storage of unnecessary inventories, it leaded to waiting in the warehouses for these products. However, the effect of unnecessary or excess inventory waste on overprocessing or excess processing waste is not a important relationship, but revealed a weak relationship. When the effects of other waste types on unnecessary or excess inventory waste were examined, the following results were obtained. The effect of overproduction waste and defect waste on unnecesary or excess inventory waste revealed a strong relationship. Although there is no demand from clients, overproduction wastes caused excessive production of products and piling these products in warehouses, thus unnecessary and excess inventories are created and unnecessary inventories are used to meet existing client orders. The production of defective parts that need to be reprocessed means that there are increased WIP levels in inventory form and if operatives made an error with the product, inadequacy and waste associated with checks of excess inventory levels occurred. The effect of waiting waste on unnecessary or excess inventory waste revealed a very important relationship. Waiting waste arised as unnecessary and excess inventory stack and waste of products that did not contained orders in WIP or warehouses. The effect of overprocessing or excess processing waste on unnecessary or excess inventory waste revealed a normal level of relationship. Unwanted by the client, and by not meeting the client and product needs, further excess processing or overprocessing of the product is carried out, and unnecessary inventory waste caused by the storage of excess transaction inventories in WIP. However, the effect of unnecessary or excess motion waste and transportation waste on unnecessary or excess inventory waste is not an important relationship, but revealed a weak relationship. After examining all this, the effect of other wastes on unnecessary or excess inventory waste, that is, unnecessary or excess inventory waste was found to be affected by other types of waste, with a rate of 13.07 percent. Thus, the rate at which unnecessary or excess inventory waste is affected by other waste and the rate at which overproduction waste is affected by other waste (13.07 percent) was the same.

Again, in the matrix, the effect of waiting waste on other types of waste emerged with a rate of 13.07 percent. Waiting waste with unnecessary or excessive waste of inventory, the effect rate turned out to be the same (13.07 percent), and they shared the same rank. In other words, the fourth waste that occurred most frequently in the production processes of the products of the food firm in question appears to be waiting waste. Waiting waste is waiting for processes that are out of synchronized, and an employee or machine is waiting idle, not doing anything. When the waste relationship values were examined, the following results emerged. When the effect of waiting waste on other types of waste was examined, the effect on unnecessary or excess inventory waste and defect waste revealed a very important relationship. Waiting waste arise as unnecessary and excess inventory stack and waste of products that did not contained orders in WIP or warehouses. Waiting products caused defective products to appear due to improper conditions, for example, spoilage products or damage to the products due to waiting. The effect of waiting waste on unnecessary or excess motion waste and transportation waste revealed an important relationship. In order to realize the next process, it increased the workers waiting for the product or material from the previous process to turned to other activities at that time and made unnecessary or excess motion. Reductions in transport activities occurred when products did not moved within a facility when workers and machines wait for an operation to finish, or wait for the next action. The effect of waiting waste on overproduction waste and overprocessing or excess processing waste revealed a normal level of relationship. A worker who is responsible for a machine left the front of the machine to carry out other activities, and this generated waiting, and due to the fact that this machine did not stay idle but only works for work, it is forced into overproduction. Products are waiting when did processed, and the used of small and flexible machines became increased to reduced waiting and prevent overprocessing or excess processing waste. When the effects of other waste types on waiting waste were examined, the following results were obtained. The effect of overproduction waste on waiting waste revealed a strong relationship. Due to overproduction, more worked is carried out in a production process and there are waiting until the previous process is passed to the next process, and with the overproduction of the products, the products waiting in the warehouses became spoilage or damaged, and the waste increased, and in this case, when there is demand from clients they had to wait as these products did not meet their expectations. The effect of overprocessing or excess processing waste on waiting waste revealed a very important relationship. When an imbalance occurred in the production schedule, and there are times when workers and machines did idle or not working, there is waiting and waste for the product. The effect of defect waste, unnecessary or excess motion waste, and transportation waste on waiting waste revealed an important relationship. When defective products are sent to stations for reprocessing, if not processed, a waiting occurred and thus other defective products entered the queue, increased the waiting time. Unnecessary or excess motion of the employees, removed them from the actual product that needed to be processed, and did other jobs caused these products to waited and turned into waste. If the product did not be processed, it did not move in a production process and within the factory and expects to move from one warehouse to another or from one place to another. If it was a finished product, it was then carried out waiting for the previous products to be transported. These caused the formation of waste. The effect of unnecessary or excess inventory waste on waiting waste revealed a normal level of relationship. Along with the storage of unnecessary inventories, it leaded to waiting in the warehouses for these products. After examining all this, the effect of other wastes on waiting waste, that is, waiting waste was found to be affected by other types of waste, with a rate of 14.20 percent.

Fifthly, in the matrix, the effect of transportation waste on other types of waste emerged with a rate of 12.5 percent. In other words, the fifth waste that occurred most frequently in the production processes of the products of the food firm in question appears to be transportation waste. Transportation waste occurs during the production process when products are moved from one warehouse to another or from one place to another. When the waste relationship values were examined, the following results emerged. When the effect of transportation waste on other types of waste was examined, the effect on defect waste revealed strong relationship. While the products are transported from one warehouse to another warehouse or from one place to another, faulty products are also transported and quality problems and wastes related to the product arised. The effect of transportation waste on unnecessary or excess motion waste revealed a very important relationship. Unnecessary or excess motion during the transportation of products from one warehouse to another warehouse or from one place to another - that is, by body movements such as walking, lifting, carrying while the employees do their work - caused waste to became formed. The effect of transportation waste on overproduction waste and waiting waste revealed a important relationship. While the products are transported from one warehouse to another warehouse or from one place to another, the waste generated as a result of unnecessary movements between the processes increased the effort due to the transportation of many products resulted from overproduction. If the product did not be processed, it was not move in a production process and within the factory and expects to move from one warehouse to another or from one place to another. If it was a finished product, it was then carried out waiting for the previous products to become transported. These caused the formation of waste. However, the effect of transportation waste on unnecessary or excess inventory waste and overprocessing or excess processing waste is not an important relationship, but revealed a weak relationship. When the effects of other waste types on transportation waste are examined, the following results have obtained. The effect of overproduction waste and defect waste on transportation waste revealed a strong relationship. Overproduction wastes leaded to more transported of materials or products from one station to another or from one warehouse to another in case of overproduction of products. If defective parts or products are produced, moved them to rework stations or from one process to another, from one warehouse to another, increased transport activity waste. The effect of unnecessary or excess inventory waste on transportation waste revealed a very important relationship. High inventory levels, moved these inventories from one warehouse to another, or went and returned between warehouses and blocking existing aisles caused a production activity to have a higher transportation time and cost. The effect of unnecessary or excess motion waste, overprocessing or excess processing waste and waiting waste on transportation waste has revealed an important relationship. The fact that employees did their jobs by making unnecessary or excess motion further increased their transportation activities and wastes. Transporting the products that are overprocessed or to be processed from one warehouse to another or from one place to another caused waste, time, and costs to increase. Reductions in transportation activities occurred when products did not move within a facility when workers and machines waited for an operation to finished, or waited for the next action. After examining all this, the effect of other wastes on transportation waste, that is, transportation waste was found to be affected by other types of waste, with a rate of 15.91 percent. Thus, together with this rate, it emerged as the second waste, which was most affected by other types of waste, after defect waste and unnecessary or excess motion waste.

Lastly, in the matrix, the effect of unnecessary or excess motion waste on other types of waste emerged with a rate of 10.79 percent. In other words, the last waste that occurred most frequently in the production processes of the products of the food firm in question appears to be unnecessary or excess motion waste. Unnecessary or excess motion waste is associated with poor ergonomics, and employee’s movements such as walking, lifting, and carrying are unnecessary or excessive. When the waste relationship values were examined, the following results obtained. The effect of unnecessary or excess motion waste on other waste, when examined, on defect waste, transportation waste and waiting waste revealed an important relationship. Employees who moved, walked or lifted excessively in a production process got tired, showed lower productivity, provided an inefficient flow of goods, and produced faulty products and waste. The fact that employees did their jobs by made unnecessary or excess motion further increased their transportation activities and wastes. Unnecessary or excess motion of the employees, removed them from the actual product that needed to became processed, and did other jobs caused these products to waited and turned into waste. The effect of necessary or excess motion waste on overproduction and overprocessing or excess waste revealed a normal level of relationship. Made unnecessary or excess motion of the employees, they kept them from a certain amount of products they need to made or produced, caused more overproduction and waste. The reduction of unnecessary or excess motion of the employees in the processes became realized by the firm’s continued the production processes by used small and flexible machines, not by use large and inflexible machines to show that there is a strong relationship between the machine and the employees. However, the effect of unnecessary or excess motion waste on unnecessary or excess inventory waste is not an important relationship, but revealed a weak relationship. When the effect of other types of waste on unnecessary or excess motion waste is examined, the following results obtained. The effect of defect waste on motion waste revealed a strong relationship. It occurred by restricting the body movements of the employees in connection with the production of a defective product, had a bad job, and settlement arrangement. The effect of overproduction waste, unnecessary or excess inventory waste, transportation waste and overprocessing or excess processing waste on unnecessary or excess motion waste revealed a very important relationship. Overproduction wastes caused an irregular workplace due to a bad ergonomic structure and overproduction, and consequently the used of workers or equipment that moved too much, walked, that is, showed excessive body motion. Moved a high level of inventory to warehouses caused increased movement of workers by walked or lifted them, and in poor and irregular storage areas, these movements increased further and reduced productivity. Unnecessary or excess motion during the transportation of products from one warehouse to another warehouse or from one place to another - that is, by body movements such as walked, lifted, carried while the employees did their work - caused waste to become formed. In overprocessing or excess processing, when food firm chose large and inflexible machines for their production instead of small and flexible machines, it caused the body movements of the employees to became unnecessary or excessive, caused the waste to become generated and both tired them and caused long delivery times. The effect of waiting waste on unnecessary or excess motion waste revealed an important relationship. In order to realize the next process, it increased the workers waiting for the product or material from the previous process to turn the other activities at that time and made unnecessary or excess motion. After examining all this, the effect of other wastes on unnecessary or excess motion waste, that is, unnecessary or excess motion waste was found to be affected by other types of waste, with a rate of 16.48 percent. Thus, unnecessary or excess motion waste emerged as the waste most affected by other types of waste, such as defect waste with 16.48 percent.

In summary, the lean wastes that most occur during the production processes of the food firm in question are (the effect of a waste on other waste), respectively; Overproduction waste with a rate of 18.75 percent; Defect waste with a rate of 18.18 percent; Overprocessing or excess processing waste with a rate of 13.64 percent; Unnecessary or excess inventory and waiting waste with a rate of 13.07 percent; Transportation waste with a rate of 12.5 percent; and Unnecessary or excess motion waste with a rate of 10.79 percent. Also, in the matrix, these results were taken into account, as the significance of the effect of a waste on other waste is greater for the food firm in question.

Also, wastes affected by other wastes, respectively; Defect waste and unnecessary or excess motion waste with a rate of 16.48 percent; Transportation waste with a rate of 15.91 percent; Waiting waste with a rate of 14.20 percent; Overproduction waste and unnecessary or excess inventory waste with a rate of 13.07 percent; and

Overprocessing or excess processing waste with a rate of 10.79 percent.

4.4. Results of Research Method of BWM

The criteria were determined by the same focus group of ten expert people as described above. These criteria were determined by the answers they gave to the question ‘Which lean production tools do you use in your firm?’, which was asked through a questionnaire. A total of seven lean production tools criteria were determined. Because it was aimed to determine seven lean production tools against seven lean wastes. These criteria are as seen on Table 4.2.

Table 4.2. Criteria of Lean Production Tools

Criteria Number	c_1	c_2	c_3	c_4	c_5	c_6	c_7
Names of Criteria	Kaizen	5S	SMED	Visual Management System	TPM	Poka-Yoke	Hoshin Kanri

Between these criteria, the best and worst criteria were determined by an expert focus group of ten people. So, DM are focus group. The best criterion was defined as the (c_b) Kaizen lean production tool and the worst criterion as the (c_w) Hoshin Kanri lean production tool. Since the Kaizen lean production tool, which is determined as the best criterion, is the core concept of lean production, eliminates waste, and has the purpose of constant healing, it has been determined as the most desired and most significant criterion. The Hoshin Kanri lean production tool, which is determined as the worst criterion, was determined as the least desired and least significant criterion due to the firm’s ability to develop policies and plans for its activities.

The preference ratio of the best criterion was determined according to whole other criteria. Then, the preferred ratio of the worst criterion was determined, according to whole other criteria. This preference ratio was determined using a number between 1 and 9. The preference ratio from 1 to 9 are as follows. The determined preference ratios are as seen on Table 4.3 and Table 4.4.

1: Equally siginificant

2: Between Equal and Moderate

3: Moderately more significant

4: Between Moderate and Strong

5: Strongly more significant

6: Between strong and very strong

7: Very strongly significant

8: Between very strong and extreme

9: Extremely siginificant

Table 4.3. Preference Ratio of Best-to-Others (A_B)

Best-to-Others	Kaizen	5S	SMED	Visual Management System	TPM	Poka-Yoke	Hoshin Kanri
Kaizen	**1**	5	4	4	3	6	4

Table 4.4. Preference Ratio of Others-to-Worst (A_W)

Others-to-Worst	Hoshin Kanri
Kaizen	4
5S	3
SMED	3
Visual Management System	3
TPM	4
Poka-Yoke	5
Hoshin Kanri	**1**

According to Table 4.3 and Table 4.4, 'Best-to-Others' (A_B) and 'Others-to-Worst' (A_W) vectors emerged.

$$A_B = (1, 5, 4, 4, 3, 6, 4), \text{ and } A_W = (4, 3, 3, 3, 4, 5, 1).$$

A linear programming model was established and optimum weights were obtained. Accordingly, the weight of each criterion and the ranking of these weight of criteria were obtained. Also, a CR was obtained with the value of ξ. These results are as seen on Table 4.5.

Table 4.5. Weights of Criteria and Consistency Ratio

Weights	**Kaizen**	**5S**	**SMED**	**Visual Management System**	**TPM**	**Poka-Yoke**	**Hoshin Kanri**
	0,3477	0,1007	0,1258	0,1258	0,1678	0,0839	0,0479
Ranking	1	4	3	3	2	5	6

ξ	0,1558

4.4.1. Analysis of Results of BWM and Combining WRM and BWM

According to the weights determined by BWM, as shown in Table 4.5, the weights of the lean production tools used by the food firm in question were Kaizen, TPM, SMED, Visual Management System, 5S, Poka-Yoke, and Hoshin Kanri, respectively. Also, this ranking is as seen on Figure 4.3. With the 0,1558 ratio, considering the CR (**ξ**), it is possible to say that the comparisons of focus group are consistent.

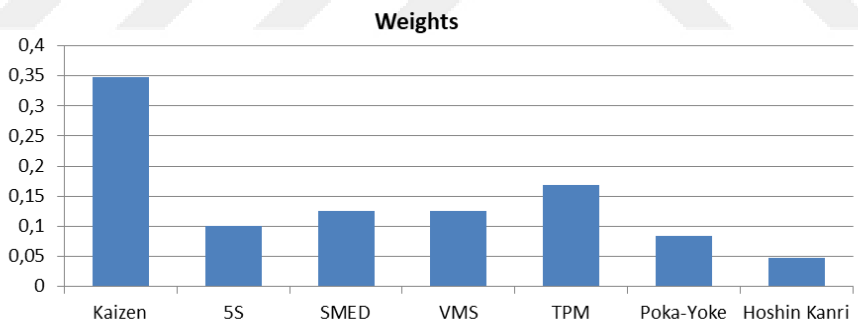

Figure 4.3. Weights of Criteria

WRM and BWM were combined. According to the results obtained with WRM, the ranking of the lean wastes generated in the food firm in question was obtained. It was aimed to use lean production tools to reduce and eliminate these lean wastes. Therefore, for the food firm in question, a relationship was established between lean wastes and lean production tools, after the lean production tools corresponding to each waste emerged according to the weights determined by BWM. The ranking of lean wastes and lean production tools from the highest percentage and weight to the lowest percentage and weight is as seen on Table 4.6.

Table 4.6. Ranking of Lean Wastes and Lean Production Tools with Determined WRM and BWM

Rank	Lean Wastes	Percent (%)	Lean Production Tools	Weights
1	Waste of Overproduction	18.75 %	Kaizen	0,3477
2	Waste of Defect	18.18 %	TPM	0,1678
3	Waste of Overprocessing or excess processing	13.64 %	SMED and Visual Management System	0,1258
4	Waste of Unnecessary or excess inventory and Waste of Waiting	13.07 %	5S	0,1007
5	Waste of Transportation	12.5 %	Poka-Yoke	0,0839
6	Waste of Unnecessary or excess motion	10.79 %	Hoshin Kanri	0,0479

Firstly, in the firm, it turned out that by using the Kaizen lean production tool (0,3477), which corresponds to the overproduction waste that occurred (18.75 percent), this type of waste can be reduced and eliminated. Kaizen lean production tool is a significant tool because it is the core concept of lean production, eliminates waste, and has the purpose of constant healing. Overproduction waste occurs in cases of excess or premature production. It can be said that the reduction of this waste can be achieved by the Kaizen lean production tool providing constant healing in production and preventing material waste due to overproduction. The accumulation of unnecessary or excess inventory due to overproduction causes the employees to make the extra effort and decreases their motivation to work. Since the focus of the Kaizen lean production tool is employees, it is based on increasing their knowledge and skills, and motivation. Thus, by using the Kaizen lean production tool, it can be said that with reducing and eliminating this type of waste, productivity and quality increase, innovation and creativity, and actions that create permanent added value can be realized.

Secondly, in the firm, it turned out that by using the TPM lean production tool (0,1678) which corresponds to the defect waste that occurred (18.18 percent), this type of waste can be reduced and eliminated. The TPM lean production tool is a significant tool as it enables employees to maximize the efficiency of the machinery and equipment they are working on. By maintaining this tool, machinery, and equipment, and reducing malfunction situations, reduces the production of faulty products in production processes. Defect waste causes the production of faulty products, together with poor control of operations, and this type of waste arises due to the inadequacy of employees and lack of skills. Thus, by using the TPM lean production tool, it can be said that with reducing and eliminating this type of waste, by controlling and maintaining operations and machinery and equipment, a significant reduction in the number of failures, increasing the productivity and efficiency of machinery and equipment, and with reducing failure in failure in product quality that the emergence of defective products can be prevented.

Thirdly, in the firm, it turned out that by using the SMED and the Visual Management System lean production tools (0,1258) corresponds to the overprocessing or excess processing waste occurred (13.64 percent), this type of waste can be reduced or eliminated. The SMED lean production tool is an significant tool associated with production that can be applied to machines and is small batch and flexible. Overprocessing pr excess processing waste arises when small and flexible machines are not preferred, but large and inflexible machines are preferred. Thus, by using the SMED lean tool, it can be said that with reducing and eliminating this type of waste, it can be said that more flexible responses to client demands will be provided by performing smaller batch production on small and flexible machines. The Visual Management System lean production tool is a significant tool that enables employees to be more efficient in their work by using visual systems. In the production process, overprocessing or excess processing waste is when a worker sends a product to the other worker for the next process, if that worker is not ready to process that product, it causes the products to be processed in the WIP and the formation of waste. In this case, products with a quality that clients do not want emerge. Thus, by using the Visual Management System lean production tool, it can be said that with reducing and eliminating this type of waste, workers can control their work, monitor the production and quality status of products with signals and other visual systems (such as visual display, visual control).

Fourthly, in the firm, it turned out that by using the 5S lean production tool (0,1007), which corresponds to the unnecessary or excess inventory waste and waiting waste occurred (13.07 percent), this type of waste can be reduced or eliminated. The 5S lean production tool is a significant tool that increases workforce productivity, reduces waste, and ensures that the firm is clean and tidy. When unnecessary or excess inventory waste does not include client orders, products are damaged, as a result of premature or overproduction, these inventories accumulate in warehouses. It can be said that with reducing and eliminating of this type of waste can be achieved especially with the Seiri or Sort section of the 5S lean production tool. Seiri or Sort aims to free the firm from unnecessary parts and inventory and to have a reduced amount of inventory. In unnecessary or excess inventory waste, since the number of inventories is unnecessary or excessive, the storage areas of these inventories are also high. Thus, by using the 5S lean production tool Seiri or Sort, it can be said that with reducing and eliminating of this type of waste can be achieved with less production, less inventory, and freeing the firm from unnecessary or excess parts and inventories. Waiting waste is the waste that does not move within the factory, awaits the next production process or machine for the product to be processed, creates a waiting queue, and reveals asynchronous processes. It can be said that with reducing and eliminating of this type of waste can be achieved especially with the Seiton or Straighten section of the 5S lean production tool. Since Seiton or Straighten is a systematic process, a suitable area is organized, determined, and selected for the machines and tools in the workstations. Thus, by using the 5S lean production tool Seiton or Straighten, it can be said that with reducing and eliminating of this type of waste can be achieved by providing simple access to machinery and tools.

Fifthly, in the firm, it turned out that by using the Poka-Yoke lean production tool

(0,0839), which corresponds to the transportation waste occurred (12.5 percent), this type of waste can be reduced or eliminated. The Poka-Yoke lean production tool is a significant tool that prevents and eliminates human errors and prevents the production of faulty products in production processes. Transportation waste is the waste that occurs while moving from one place to another or from one warehouse to another, and the products that are produced incorrectly are also transported, causing a further increase in waste. Thus, by using the Poka-Yoke lean production tool, it can be said that with reducing and eliminating of this type of waste can be realized the production of the wrong products will be prevented by the employees and the transportation of these products will be eliminated.

Finally, in the firm, it turned out that by using the Hoshin Kanri lean production tool (0,0479), which corresponds to the unnecessary or excess motion waste occurred (10.79 percent), this type of waste can be reduced or eliminated. Hoshin Kanri lean production tool is a significant tool that focuses on the ability to improve the firm's performance by achieving policy, management and strategic plans and purposes. Unnecessary or excess motion waste is associated with poor ergonomics and firm regulation, and unnecessary or excess motion of employees - carrying, walking, and lifting - arises. Thus, by using the Hoshin Kanri lean production tool, it can be said that with reducing and eliminating of this type of waste, the creation of an efficient layout of the firm, the examination of the processes that require excessive motions of the employees, and the use of this tool to improve the skills and training of the firm's employees, that achieving strategic goals can be realized.

The Implementation of the study explained in detail in Chapter 4. In this section, in general, the food sector in the Turkey and poultry products sector is described. Then, for data analysis and results, data collection and analysis of questionnaire answers were made. Results were obtained with WRM and BWM, and these results were analyzed. Conclusion will be explained in the next section.

CHAPTER 5
CONCLUSIONS

In summary, in this thesis, reducing waste management by applying lean production tools in the food sector is explained. A production sector determined. Reducing and eliminate the actions and wastes that do not add value in a production process in lean production, and was aimed to reduce and eliminate the seven lean wastes that emerged by applying lean production tools. A comprehensive and meticulous literature review was made on this subject. This literature review consisted of two parts. In the first part, in the lean production title; the framework of lean production, the definition of the lean concept, lean principles, history development of lean production, purposes, core components, principles, benefits, and tools were examined in detail. In the second chapter, under the title of waste management; The definition of the waste and value notion, the definitions of interrelated waste and value concept, waste elimination, waste types, seven lean waste types of lean production were examined in detail.

In the methodology part, two methods were applied as WRM method and BWM for this thesis. Seven lean wastes are overproduction, waiting, unnecessary or excess motion, transportation, overprocessing or excess processing, unnecessary or excess inventory, and defect wastes. These lean wastes were taken as the basis of wastes that need to be reduced and disposed of. For this, in line with the purpose of this thesis, a expert focus group of ten people operating in the lean systems department of a firm that produces poultry products in a food firm in the production sector was formed. The WRM method was used to identify the lean wastes generated in this food firm and to measure the relationship between these seven lean wastes. The purpose of the WRM method was to measure and evaluate the effect of waste on other wastes and the affected of waste on other wastes. Questions were sent to the focus group based on the developed questionnaire-based measurement criteria, which should be answered in connection with the waste relationship definitions

(Rawabzadeh, 2005). WRM was created according to the answers to the questions asked. As a result, the wastes emerged in the production processes in the firm are, respectively, Overproduction waste with a rate of 18.75 percent; Defect waste with a rate of 18.18 percent; Overprocessing or excess processing waste with a rate of 13.64 percent; Unnecessary or excess inventory and waiting waste with a rate of 13.07 percent; Transportation waste with a rate of 12.5 percent; and Unnecessary or excess motion waste with a rate of 10.79 percent. In the matrix, these results were taken into account, as the significance of the effect of a waste on other waste is greater for the food firm in question. Looking at these results, it turned out that the effect of overproduction waste on all waste is large and important. It was also supported in the literature review that overproduction waste effects and dominates other waste (Kobayashi, 1995; Wahab et al., 2013). Also, in the firm, in the production process, wastes affected by other wastes, respectively; Defect waste and unnecessary or excess motion waste with a rate of 16.48 percent; Transportation waste with a rate of 15.91 percent; Waiting waste with a rate of 14.20 percent; Overproduction waste and unnecessary or excess inventory waste with a rate of 13.07 percent; and Overprocessing or excess processing waste with a rate of 10.79 percent. Considering the results obtained, it was revealed that the WRM method contributed to obtaining the correct results due to its simplicity and understandability. With WRM, the importance of the lean waste types that emerged was ranked and allowed the determination of the source of waste generated in the firm.

Later, it was aimed to use lean production tools to reduce and eliminate these lean wastes. BWM was used for this. The purpose of BWM is to determine the best and worst criteria before making binary comparisons among the specified criteria, then to compare the best determined criterion with other criteria and compares all other criteria with the worst determined criterion. As a result, to obtain more reliable and consistent comparisons. Again, regarding the questionnaire-based measurement criteria sent to the same focus group, according to the answers from the questions, the lean production tool criteria were determined by the focus group as Kaizen, 5S, SMED, Visual Management System, TPM, Poka-Yoke, and Hoshin Kanri. With BWM, the best criterion Kaizen lean production tool, and the worst criterion Hoshin Kanri lean production tool were determined. The preference ratio of the best criterion was determined according to whole other criteria. Then, the preferred ratio of the worst criterion was determined, according to whole other criteria. This preference ratio was determined using a number between 1 and 9. Optimum weights and CR of the criteria were obtained with the linear programming model. According to these results, optimum weights of lean production tools are respectively, Kaizen (0,3474), TPM (0,1678), SMED and Visual Management System (0,1258), 5S (0,1007), Poka-Yoke (0,1839), and Hoshin Kanri (0,0479). In addition, it was found that the comparisons made with the CR (ξ), 0,1558 are reliable and consistent.

Finally, these two methods were combined. With the ranking of lean wastes obtained by the WRM method and the weights of lean production tools obtained with BWM, lean production tools corresponding to each lean waste emerged and a relationship was established between lean wastes and lean production tools. Taking this relationship into account, the food firm uses the resulting lean production tools to reduce and eliminate these lean wastes generated in its firms. With the application of these lean production tools, the reduction and elimination of lean waste ensure that the food firm’s production activities are more efficient and productive. In addition, it prevents the occurrence of NVA activities created by these lean wastes in the production processes in the food firm, and with the implementation of lean production tools, more VA activities begin to occur. Thus, thanks to lean production tools with the removal of lean wastes from the production processes of the food firm, there is a decrease in costs, an increase in productivity, profitability, the quality of the products they produce, and the satisfaction levels of their clients. This will bring the food firm to a higher and more important position in business skills compared to other competitors, and the ratio of preference those by clients will be higher.

REFERENCES

Abdallah, A. B., & Matsui, Y. (2007, July). JIT and TPM: Their relationship and impact on JIT and competitive performances. In *Conference of the International Decision Sciences Institute (DSI), Bangkok, Thailand*.

Abdallah, A. B., Dahiyat, S. E., & Matsui, Y. (2019). Lean management and innovation performance. *Management Research Review*.

Abdallah, A., & Phan, C. A. (2007). The relationship between just-in-time production and human resource management, and their impact on competitive performance. *Yokohama Business Review*, *28*(2), 27-57.

Abdulmalek, F. A., & Rajgopal, J. (2007). Analyzing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study. *International Journal of production economics*, *107*(1), 223-236.

Adalı, M. R., Kiraz, A., Akyüz, U., & Halk, B. (2017). Yalın üretime geçiş sürecinde değer akışı haritalama tekniğinin kullanılması: Büyük ölçekli bir traktör işletmesinde uygulama. *Sakarya University Journal of Science*, *21*(2), 242-251.

Åhlström, P. (1998). Sequences in the implementation of lean production. *European Management Journal*, *16*(3), 327-334.

Ahmad, W. N. K. W., Rezaei, J., Sadaghiani, S., & Tavasszy, L. A. (2017). Evaluation of the external forces affecting the sustainability of oil and gas supply chain using Best Worst Method. *Journal of cleaner production*, *153*, 242-252.

Ahmadi, H. B., Kusi-Sarpong, S., & Rezaei, J. (2017). Assessing the social sustainability of supply chains using Best Worst Method. *Resources, Conservation and Recycling*, *126*, 99-106.

Aka, A., Isah, A. D., Eze, C. J., & Timileyin, O. (2019). Application of lean manufacturing tools and techniques for waste reduction in Nigerian bricks production process. *Engineering, Construction and Architectural Management*.

Al Mouzanı, I. M. A. N. E., & Bouamı, D. (2019). The Integratıon Of Lean Manufacturıng And Lean Maıntenance To Improve Productıon Effıcıency. *International Journal Of Mechanical And Production Engineering Research And Development (Ijmperd)*, *9*(1), 593-604.

Al-Aomar, R. (2012). Analysis of lean construction practices at Abu Dhabi construction industry. *Lean Construction Journal*, Vol. 8 No. 1, pp. 105-121.

Al-Aomar, R. A. (2011). Applying 5S LEAN Technology: An infrastructure for continuous process improvement. *World Academy of Science, Engineering and Technology*, *59*(2011), 2014-2019.

Albliwi, S. A., Antony, J., & halim Lim, S. A. (2015). A systematic review of Lean Six Sigma for the manufacturing industry. *Business Process Management Journal*, *21*(3), 665-691.

Alcaraz, J. L. G., Maldonado, A. A., Iniesta, A. A., Robles, G. C., & Hernández, G. A. (2014). A systematic review/survey for JIT implementation: Mexican maquiladoras as case study. *Computers in Industry*, *65*(4), 761-773.

Alhyari, S. (2015). Supply Chain Management Paradigms and Their Impact on Competitive Priorities: An Applied Study on Jordanian Airlines Industry. *Unpublished PhD thesis, The World Islamic Sciences and Education University, Jordan*.

Allen, D. M. (1994). Waste minimisation and treatment: an overview of technologies. *Greener Management International*, 22-28.

Allen, J., Rabinson, C., & Steward, D. (2001). *Lean Manufacturing*, Society of Manufacturing Engineers, USA.

Anand, G., & Kodali, R. (2008). A conceptual framework for lean supply chain and its implementation. *International Journal of Value Chain Management*, *2*(3), 313-357.

Anđelković, A., Radosavljević, M., & Stošić, D. (2016). Effects of Lean tools in achieving Lean warehousing. *Economic Themes*, *54*(4), 517-534.

Ankara Sanayi Odası – Muhtelif Gıda Sektörü. (2019). Retrieved 15 March 2021, from https://www.aso.org.tr

Antony, J., Agus, A., & Hajinoor, M. S. (2012). Lean production supply chain management as driver towards enhancing product quality and business performance. *International Journal of Quality & Reliability Management*, *29*(1), 92–121.

Antony, J., Douglas, J., & Douglas, A. (2015). Waste identification and elimination in HEIs: the role of Lean thinking. *International Journal of Quality & Reliability Management*, *32*(9), 970-981.

Antony, J., Escamilla, J. L., & Caine, P. (2003). Lean Sigma [production and supply chain management]. *Manufacturing Engineer*, *82*(2), 40-42.

Antosz, K., Pacana, A., Stadnicka, D., & Zielecki, W. (2015). Lean Manufacturing. *Doskonalenie produkcji,[Lean Manufacturing. Improving production]. Rzeszów, Poland: Wydawnictwo Politechniki Rzeszowskiej*.

Arbulu, R., Tommelein, I., Walsh, K., & Hershauer, J. (2003). Value stream analysis of a re-engineered construction supply chain. *Building Research & Information*, *31*(2), 161-171.

Arezes, P., Carvalho, D., & Alves, A. C. (2010). Threats and opportunities for workplace ergonomics in lean environments. EurOMA.

Arif-Uz-Zaman, K., & Ahsan, A. N. (2014). Lean supply chain performance measurement. *International Journal of Productivity and Performance Management*, *63*(5), 588-612.

Arnheiter, E. D., & Maleyeff, J. (2005). The integration of lean management and Six Sigma. *The TQM magazine*, *17*(1), 5-18.

Arunagiri, P., & Gnanavelbabu, A. (2016). Identification of major lean waste and its contributing factors using the fuzzy analytical hierarchy process. *Transactions of the Canadian Society for Mechanical Engineering*, *40*(3), 371-382.

Ashish B. (2009). "Textbook of Supply Chain Management" – Global Media, Lucknow, IND. 195 p.

Aslan, H. M. (2017). "Determination of Optimal Vehicle Selection of Logistics Companies with AHP-ARAS Hybrid Method". *The Journal of Operations Research, Statistics, Econometrics and Management Information Systems, 5*(2), 272-282.

azimi Jibril, J. D., Sipan, I. B., Sapri, M., Shika, S. A., Isa, M., & Abdullah, S. (2012). 3R s critical success factor in solid waste management system for higher educational institutions. *Procedia-Social and Behavioral Sciences*, *65*, 626-631.

Baskaran, S. M. (2018). Ranking of lean tools using weighted scoring method. *Transportation*, *30*, 0-30.

Baysan, S., Kabadurmus, O., Cevikcan, E., Satoglu, S. I., & Durmusoglu, M. B. (2019). A simulation-based methodology for the analysis of the effect of lean tools on energy efficiency: An application in power distribution industry. *Journal of cleaner production*, *211*, 895-908.

Bellido, Y., La Rosa, A., Torres, C., Quispe, G., & Raymundo, C. (2018). Waste optimization model based on Lean Manufacturing to increase productivity in micro-and small-medium enterprises of the textile sector, *1*, 148-153.

Bhasin, S., & Burcher, P. (2006). Lean viewed as a philosophy. *Journal of manufacturing technology management*, *17*(1), 56-72.

Bianciardi, A., Credi, C., Levi, M., Rosa, F., & Zecca, A. (2017). Biomimicry thinking: methodological improvements and practical implementation. *Bioinspired, Biomimetic and Nanobiomaterials*, *6*(2), 87-101.

Bicheno, J., & Holweg, M. (2000). *The lean toolbox* (Vol. 4). Buckingham: PICSIE books.

Bicheno, J., Anhede, P., Hillberg, J., & Holweg, M. (2011). *Ny verktygslåda för Lean: Filosofi, transformation, metoder och verktyg*. Revere.

Bichero J. (1998). *The Lean Toolbox.* 2nd Ed. Buckinham: PICSIE Books.

Bortolotti, T., Boscari, S., & Danese, P. (2015). Successful lean implementation: Organizational culture and soft lean practices. *International Journal of Production Economics*, *160*, 182-201.

Bozdogan K. (2006). *A comparative review of lean thinking, six sigma and related enterprise process improvement initiatives.* Working paper, 060531. MIT, Cambridge.

Braglia, M., Carmignani, G., & Zammori, F. (2006). A new value stream mapping approach for complex production systems. *International journal of production research*, *44*(18-19), 3929-3952.

Brown, A., Amundson, J., & Badurdeen, F. (2014). Sustainable value stream mapping (Sus-VSM) in different manufacturing system configurations: application case studies. *Journal of Cleaner Production*, *85*, 164-179.

Browning, T. R., & Heath, R. D. (2009). Reconceptualizing the effects of lean on production costs with evidence from the F-22 program. *Journal of operations management*, *27*(1), 23-44.

Bulut, K., & Altunay, H. (2016). Değer akışı haritalandırma yöntemi: mobilya sektöründe bir uygulama. *Uluslararası Mühendislik Araştırma ve Geliştirme Dergisi*, *8*(1), 48-55.

Burton, T. T., & Boeder, S. M. (2003). *The lean extended enterprise: Moving beyond the four walls to value stream excellence*. J. Ross publishing.

Caldera, H. T. S., Desha, C., & Dawes, L. (2017). Exploring the role of lean thinking in sustainable business practice: A systematic literature review. *Journal of Cleaner Production*, *167*, 1546-1565.

Campos, L. M., & Vazquez-Brust, D. A. (2016). Lean and green synergies in supply chain management. *Supply Chain Management: An International Journal*, *21*, 627-641.

Capital, M. (2004). Introduction to lean manufacturing for Vietnam. *Published Article by Mekong Capital Ltd*.

Carvalho, H., & Azevedo, S. (2014). Trade-offs among lean, agile, resilient and green paradigms in supply chain management: a case study approach.

In *Proceedings of the seventh international conference on management science and engineering management* (pp. 953-968). Springer, Berlin, Heidelberg.

Carvalho, H., Duarte, S., & Machado, V. C. (2011). Lean, agile, resilient and green: divergencies and synergies. *International Journal of Lean Six Sigma*.

Castillo, G., Alarcón, L. F., & González, V. A. (2015). Implementing lean production in copper mining development projects: Case study. *Journal of Construction Engineering and Management*, *141*(1), 05014013.

Chahal, V., & Narwal, M. (2017). Impact of lean strategies on different industrial lean wastes. *International Journal of Theoretical and Applied Mechanics*, *12*(2), 275-286.

Chan, F. T. S. (2001). Effect of kanban size on just-in-time manufacturing systems. *Journal of materials processing technology*, *116*(2-3), 146-160.

Chandrasekaran, M., Kannan, S., & Pandiaraj, P. (2008). Quality improvement in automobile assembly production line by using Kaizen. *Manufacturing Technology Today*, *7*(3), 33-38.

Chase, J. P. (2001). *Value creation in the product development process* (Doctoral dissertation, Massachusetts Institute of Technology).

Chase, R. B., Jacobs, F. R., & Aquilano, N. J. (2004). *Operations Management*, McGraw-Hill/Irwin, New-York.

Chavez, R., Gimenez, C., Fynes, B., Wiengarten, F., & Yu, W. (2013). Internal lean practices and operational performance. *International Journal of Operations & Production Management*, *33*, 562-588.

Chen, G. (2017). *Lean Supply Chain Management in SMEs: A Case Study of a New Zealand Company* (Doctoral dissertation, University of Otago).

Chen, J. C., Cheng, C. H., & Huang, P. B. (2013). Supply chain management with lean production and RFID application: A case study. *Expert Systems with applications*, *40*(9), 3389-3397.

Chiarini, A. (2013). The seven wastes of lean organization. In *Lean organization: From the tools of the Toyota production system to lean office* (pp. 15-30). Springer, Milano.

Chiarini, A. (2014). Sustainable manufacturing-greening processes using specific Lean Production tools: an empirical observation from European motorcycle component manufacturers. *Journal of Cleaner Production*, *85*, 226-233.

Christopher, M., & Towill, D. (2001). An integrated model for the design of agile supply chains. *International Journal of Physical Distribution & Logistics Management*.

Čiarnienė, R., & Vienažindienė, M. (2012). Lean manufacturing: theory and practice. *Economics and management*, *17*(2), 726-732.

Čiarnienė, R., & Vienažindienė, M. (2015). An empirical study of lean concept manifestation. *Procedia-Social and Behavioral Sciences*, *207*, 225-233.

Cook, C. R., & Graser, J. C. (2001). *Military airframe acquisition costs. The effects of lean manufacturing* (No. RAND/MR-1325-AF). RAND CORP SANTA MONICA CA.

Corbett, L. M. (2011). Lean Six Sigma: the contribution to business excellence. *International Journal of Lean Six Sigma*, *2*(2), 118-131.

Corvellec, H. (2016). A performative definition of waste prevention. *Waste management*, *52*, 3-13.

Crandall, K. J., Zagdsuren, B., Schafer, M. A., & Lyons, T. S. (2016). Static and Active Workstations for Improving Workplace Physical Activity and Sitting Time. *International Journal of Human Movement and Sports Sciences*, *4*(2), 20-25.

Cua, K. O., McKone, K. E., & Schroeder, R. G. (2001). Relationships between implementation of TQM, JIT, and TPM and manufacturing performance. *Journal of operations management*, *19*(6), 675-694.

Czarnecka, A., Butor, A., & Halemba, M. (2017). Lean supply chain management. *World Scientific News*, *72*, 177-183.

Çakırkaya, M., & Acar, Ö. E. (2016). 5s Tekniği Aşamaları Ve Makarna Sektöründe Bir Uygulama. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi*, *30*(4), 845-868.

Çanakçıoğlu, M. (2019). Yalın Düşünce Felsefesinde İsrafla Mücadele Araçları. *Sosyal Bilimler Araştırma Dergisi*, *8*(3), 270-282.

Çelikçapa, F. O. (2000). *Üretim yönetimi ve teknikleri*. Alfa.

Çiçekgil, Z., & Yazıcı, E. (2016). Türkiye'de tavuk yumurtası mevcut durumu ve üretim öngörüsü. *Tarım Ekonomisi Araştırmaları Dergisi*, *2*(2), 26-34.

Dahlgaard, J. J., & Dahlgaard-Park, S. M. (2006). Lean production, six sigma quality, TQM and company culture. *The TQM magazine*, *18(*3), 263-281.

Dahlgaard, J. J., Kristensen, K., & Kanji, G. K. (1995). Total quality management and education. *Total Quality Management*, *6*(5), 445-456.

Dal Forno, A. J., & Forcellini, F. A. (2012). Lean product development–principles and practices. *Product: Management and Development*, *10*(2), 131-143.

Danese, P., Manfè, V., & Romano, P. (2018). A systematic literature review on recent lean research: state-of-the-art and future directions. *International Journal of Management Reviews*, *20*(2), 579-605.

Danese, P., Romano, P., & Bortolotti, T. (2012). JIT production, JIT supply and performance: investigating the moderating effects. *Industrial Management & Data Systems*, *112*(3), 441-465.

Darlington, R., Staikos, T., & Rahimifard, S. (2009). Analytical methods for waste minimisation in the convenience food industry. *Waste Management*, *29*(4), 1274-1281.

Das, K. (2018). Integrating lean systems in the design of a sustainable supply chain model. *International Journal of Production Economics*, *198*, 177-190.

Davim, J. P. (Ed.). (2018). *Progress in lean manufacturing*. Springer.

de Sousa Jabbour, A. B. L., Junior, J. C. O., & Jabbour, C. J. C. (2014). Extending lean manufacturing in supply chains: a successful case in Brazil. *Benchmarking: An International Journal*, *21*(6), 1070-1083.

De Treville, S., & Antonakis, J. (2006). Could lean production job design be intrinsically motivating? Contextual, configurational, and levels-of-analysis issues. *Journal of Operations Management*, *24*(2), 99-123.

Dehdari, P. (2014). *Measuring the impact of lean techniques on performance indicators in logistics operations* (Vol. 80). KIT Scientific Publishing.

Dekier, Ł. (2012). The origins and evolution of Lean Management system. *Journal of International Studies*, *5*(1), 46-51.

Demeter, K., & Matyusz, Z. (2011). The impact of lean practices on inventory turnover. *International Journal of Production Economics*, *133*(1), 154-163.

Dennis, P. (2007). *Lean production simplified.* New York: Productivity Press.

Dettmer, H. W. (2001). Beyond Lean manufacturing: Combining Lean and the Theory of Constraints for higher performance. *Port Angeles, US*.

Dictionary by Merriam-Webster: America's most-trusted online dictionary. (2017). Retrieved 17 January 2021, from https://www.merriam-webster.com/

Dieste, M., Panizzolo, R., Garza-Reyes, J. A., & Anosike, A. (2019). The relationship between lean and environmental performance: Practices and measures. *Journal of Cleaner Production*, *224*, 120-131.

Dillon, A. P., & Shingo, S. (1985). *A revolution in manufacturing: the SMED system*. CRC Press.

Diyaley, S., & Chakraborty, S. (2019). Optimization of multi-pass face milling parameters using metaheuristic algorithms. *Facta Universitatis, Series: Mechanical Engineering*, *17*(3), 365-383.

Domingo, R. T. (2015). Identifying and eliminating the seven wastes or muda. *Asian Institute of Management, godina nepoznata*.

Doonan, J., Lanoie, P., & Laplante, B. (2005). Determinants of environmental performance in the Canadian pulp and paper industry: An assessment from inside the industry. *Ecological economics*, *55*(1), 73-84.

dos Santos, A., Vezzoli, C., & Morais, D. (2008). Linking lean production and design for sustainability on the issue of waste reduction. *Product: Management and Development*, *6*(2), 135-141.

Drew, J., Mc Callum, B., & Roggenhofer, S. (2004). Journey to lean: Making Operational Change Stick. Palgrave McMillan. *New York*.

Duarte, S., & Machado, V. C. (2017). Green and lean implementation: an assessment in the automotive industry. *International Journal of Lean Six Sigma*, *8*(1).

Dudek-Burlikowska, M., & Szewieczek, D. (2009). The Poka-Yoke method as an improving quality tool of operations in the process. *Journal of Achievements in Materials and Manufacturing Engineering*, *36*(1), 95-102.

Duggan KJ. (2012). Creating mixed model value streams: Practical lean techniques for building to demand (2ndedn.) CRC Press. New York.

Durakovic, B., Demir, R., Abat, K., & Emek, C. (2018). Lean manufacturing: Trends and implementation issues. *Periodicals of Engineering and Natural Sciences*, *6*(1), 130-143.

Durkee, J. (2008). Just what is 'lean manufacturing'anyway?. *Metal Finishing*, *106*(12), 44-46.

Dutta, E. A. B., & Banerjee, E. S. (2014). Review of lean manufacturing issues and challenges in manufacturing process. *International Journal of Research in Business Management*, *2*(4), 27-36.

Dües, C. M., Tan, K. H., & Lim, M. (2013). Green as the new Lean: how to use Lean practices as a catalyst to greening your supply chain. *Journal of cleaner production*, *40*, 93-100.

EEF Productivity Survey. (2001). Catching up with Uncle Sam: The EEF final report on US and UK manufacturing productivity.

Emiliani, M. L. (1998). Lean behaviors. *Management decision*, *36*(9), 615-631.

Emiliani, M. L. (2008). Standardized work for executive leadership. *Leadership & Organization Development Journal*, *29*(1), 24-46.

Enstitü, Y. (2007). Yalın Enstitü Derneği - Yalın Enstitü. Retrieved 15 January 2021, from https://lean.org.tr/yalin-enstitu-dernegi/

Erol, S., (2012). Yalın Yaklaşım ve Yalın Üretim, Anahtar, Şubat 20120, ss. 18-23, http://anahtar.sanayi.gov.tr/tr/news/yalin-yaklasim-ve-yalin-uretim/145

Ertuğrul, İ., Özveri, O., & Gündoğan, A. (2013). Yalın üretim sisteminin tekstil sanayinde uygulanabilirliği. *Kafkas Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *4*(6), 15-32.

Esfandyari, A., Härter, S., Javied, T., & Franke, J. (2015). A lean based overview on sustainability of printed circuit board production assembly. *Procedia CIRP*, *26*, 305-310.

Farah, M. A. (2015). *Lean supply chain management practices and organizational performance in the public water sector in Kenya* (Doctoral dissertation).

Feld, W. M. (2000). *Lean manufacturing: tools, techniques, and how to use them*. CRC press.

Fercoq, A., Lamouri, S., & Carbone, V. (2016). Lean/Green integration focused on waste reduction techniques. *Journal of Cleaner production*, *137*, 567-578.

Fernando, M. D. D., & Cadavid, L. R. (2007). Lean manufacturing measurement: the relationship between lean activities and lean metrics. *Estudios gerenciales*, *23*(105), 69-83.

Ferng, J., & Price, A. D. (2005). An exploration of the synergies between Six Sigma, total quality management, lean construction and sustainable construction. *International Journal of Six Sigma and Competitive Advantage*, *1*(2), 167-187.

Ferreira, P. O., Francescki, A. S. N., Melo, D. M., Silva, J. R., & Reichert, L. R. (2017). Lean Thinking as support to integration of Service areas. *Journal of Lean Systems*, *2*(4), 2-12.

Fisher, M. (1999). Process improvement by poka-yoke. *Work Study*, *48*(7), 264-266.

Fleischer, M., & Liker, J. K. (1997). Concurrent Integrating Product Engineering Development Across Effectiveness Organizations. *Cincinnati, OH: Hanser Gardner Publications*.

Florida, R. (1996). Lean and green: the move to environmentally conscious manufacturing. *California management review*, *39*(1), 80-105.

Forrester, P. L., Shimizu, U. K., Soriano-Meier, H., Garza-Reyes, J. A., & Basso, L. F. C. (2010). Lean production, market share and value creation in the agricultural machinery sector in Brazil. *Journal of Manufacturing Technology Management*, *21*(7), 853-871.

Gass, S. I., & Fu, M. C. (2013). Encyclopedia of operations research and management science. New York: Springer Science + Business Media.

George, M. (2002). *Lean Six Sigma: Combining Six Sigma Quality with Lean Production Speed,* McGrawHill Education, New York, NY.

George, M. (2003). *Lean Six Sigma for Service: How to Use Lean Speed and Six Sigma Quality to Improve Services and Transactions*, McGraw-Hill Education, New York, NY.

George, M.L. (2003), *Lean Six Sigma for Service,* McGraw-Hill, New York.

Ghaffari, K., Delgosha, S.M. & Abdolvand, N. (2014), “Towards cloud computing: a swot analysis on its adoption in SMEs”, *International Journal of Information Technology Convergence and Services*, *4*(2), 13-20.

Gitlow, H., Oppenheim, A., & Oppenheim, R. (1995). *Quality Management: Tools and Methods for Improvement,* Richard D. Irwin.

Goodson, R. E. (2002). Read a plant-fast. *Harvard business review*, *80*(5), 105-113.

Gopinath, S., & Freiheit, T. I. (2012). A waste relationship model and center point tracking metric for lean manufacturing systems. *IIE Transactions*, *44*(2), 136-154.

Goriwondo, W. M., Mhlanga, S., & Marecha, A. (2011). Use of the value stream mapping tool for waste reduction in manufacturing. Case study for bread manufacturing in Zimbabwe. In *Proceedings of the 2nd International Conference on Industrial*.

Govindan, K., Azevedo, S. G., Carvalho, H., & Cruz-Machado, V. (2015). Lean, green and resilient practices influence on supply chain performance: interpretive structural modeling approach. *International Journal of Environmental Science and Technology*, *12*(1), 15-34.

Görener, A., & Yenen, V. Z. (2007). İşletmelerde toplam verimli bakım çalışmaları kapsamında yapılan faaliyetler ve verimliliğe katkıları. İstanbul Ticaret Üniversitesi Fen Bilimleri Dergisi, 47-63.

Grasso, L. P. (2005). Are ABC and RCA accounting systems compatible with lean management?. *Management accounting quarterly*, *7*(1), 12-27.

Green, J. C., Lee, J., & Kozman, T. A. (2010). Managing lean manufacturing in material handling operations. *International Journal of Production Research*, *48*(10), 2975-2993.

Green, M., & Dick, M. (2001). Baseline analysis diagnoses manufacturing. *Lean Directions: The e-Newsletter of Lean Manufacturing (Society of Manufacturing Engineers)*.

Gross, J. (2005). Implementing successful kanbans: don't let fear be a barrier to improved material handling. *Industrial Engineer*, *37*(4), 36-40.

Gudem, M., Steinert, M., Welo, T., & Leifer, L. (2013). Redefining customer value in lean product development design projects. *Journal of Engineering, Design and Technology*.

Guerrero, L. A., Maas, G., & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. *Waste management*, *33*(1), 220-232.

Gunasekaran, A., & Ngai, E. W. (2012). The future of operations management: an outlook and analysis. *International Journal of Production Economics*, *135*(2), 687-701.

Guo, S., & Zhao, H. (2017). Fuzzy best-worst multi-criteria decision-making method and its applications. *Knowledge-Based Systems*, *121*, 23-31.

Gupta, A. K. (2011). A conceptual JIT model of service quality. *International Journal of Engineering Science and Technology*, *3*(3), 2214-2227.

Gupta, D. (2015). *Success using lean six sigma in terms of operations and business processes.* Anchor Academic Publishing (aap_verlag).

Gupta, H. (2018). Evaluating service quality of airline industry using hybrid best worst method and VIKOR. *Journal of Air Transport Management*, *68*, 35-47.

Gupta, H., & Barua, M. K. (2016). Identifying enablers of technological innovation for Indian MSMEs using best–worst multi criteria decision making method. *Technological Forecasting and Social Change*, *107*, 69-79.

Gupta, S., & Jain, S. K. (2013). A literature review of lean manufacturing. *International Journal of Management Science and Engineering Management*, *8*(4), 241-249.

Halim, N. H. A., Jaffar, A., Yusoff, N., & Adnan, A. N. (2012). Gravity Flow Rack's material handling system for Just-in-Time (JIT) production. *Procedia Engineering*, *41*, 1714-1720.

Hall, R. (1983). Zero Inventories, Dow Jones-Irwin, Homewood, IL, 1983. *HallZero Inventories1983*.

Hallam, C., & Contreras, C. (2016). Integrating lean and green management. *Management Decision*, *54*(9), 2157-2187.

Hampson, I. (1999). Lean production and the toyota production system or, the case of the forgoften production concepts. *Economic and industrial democracy*, *20*(3), 369-391.

Hamrol, A., Gawlik, J., & Skołud, B. (2015). *Strategie i praktyki sprawnego działania: Lean, Six Sigma i inne*. Wydawnictwo Naukowe PWN.

Harrison, A. (1992). *Just-in-Time: manufacturing in perspective*. Prentice Hall.

Hassanpour, M. (2019). Evaluation of Iranian wood and cellulose industries. *Decision making: applications in management and engineering*, *2*(1), 13-34.

Heizer, J., Heizer, J. H., & Render, B. (2007). *Operations management: student lecture guide*. Pearson Prentice Hall.

Helmold, M. (2011). Driving value in the upstream chain management through lean principles. *International Journal of Lean Thinking*, *2*(2), 1-8.

Hicks, B. J. (2007). Lean information management: Understanding and eliminating waste. *International journal of information management*, *27*(4), 233-249.

Hicks, C., Heidrich, O., McGovern, T., & Donnelly, T. (2004). A functional model of supply chains and waste. *International Journal of Production Economics*, *89*(2), 165-174.

Hidayati, J., & Shalihin, A. (2020, January). Reducing waste order production process more efficient approach effective and lean manufacturing (Journal Review). In *IOP Conference Series: Materials Science and Engineering* (Vol. 725, No. 1, p. 012001). IOP Publishing.

Hines, P., & Rich, N. (1997). The seven value stream mapping tools. *International journal of operations & production management*, Vol. 17, 46-64.

Hines, P., & Taylor, D. (2000). Going lean. *Cardiff, UK: Lean Enterprise Research Centre Cardiff Business School*, *1*, 528-34.

Hines, P., Holweg, M., & Rich, N. (2004). Learning to evolve. *International journal of operations & production management*, *24*(10), 994-1011.

Hogland, W., & Stenis, J. (2000). Assessment and system analysis of industrial waste management. *Waste Management*, *20*(7), 537-543.

Holweg, M. (2007). The genealogy of lean production. *Journal of operations management*, *25*(2), 420-437.

Hopp, W. J., & Spearman, M. L. (2004). To pull or not to pull: what is the question?. *Manufacturing & service operations management*, *6*(2), 133-148.

Houshmand, M., & Jamshidnezhad, B. (2006). An extended model of design process of lean production systems by means of process variables. *Robotics and Computer-Integrated Manufacturing*, *22*(1), 1-16.

Howell, G., & Ballard, G. (1998, August). Implementing lean construction: understanding and action. In *Proc. 6 th Ann. Conf. Intl. Group for Lean Constr*.

Hu, Q., Mason, R., Williams, S. J., & Found, P. (2015). Lean implementation within SMEs: a literature review. *Journal of Manufacturing Technology Management*.

Hüttmeir, A., De Treville, S., Van Ackere, A., Monnier, L., & Prenninger, J. (2009). Trading off between heijunka and just-in-sequence. *International journal of production economics*, *118*(2), 501-507.

Ilkım, N. Ş., & Derin, N. (2016). Dünyadan ve Türkiye'den Örneklerle Sağlık Hizmetlerinde Yalın Yönetim. *Hacettepe Sağlık İdaresi Dergisi*, *19*(4), 465-479.

Imai, M., & Kaizen, G. (1997). A commonsense, low-cost approach to management, McGrawHill, New York.

IW/MPI Census of Manufacturers. (2007). Measuring continuous improvement programs.

Jadhav, J. R., Mantha, S. S., & Rane, S. B. (2014). Exploring barriers in lean implementation. *International Journal of Lean Six Sigma*, *5*(2), 122-148.

Jassim, A. K. (2018). The effect of the application of lean production and supply chain management on the quality of public administration services:(Case study: Hussein Educational Hospital in Thi Qar). *International Journal of Supply Chain Management*, *7*(4), 446-455.

Jasti, N. V. K., & Kodali, R. (2015). Lean production: literature review and trends. *International Journal of Production Research*, *53*(3), 867-885.

Jayaram, A. (2016, December). Lean six sigma approach for global supply chain management using industry 4.0 and IIoT. In *2016 2nd international conference on contemporary computing and informatics (IC3I)* (pp. 89-94). IEEE.

Jedynak, P. (2015). Lean management implementation: Determinant factors and experience. *Jagiellonian Journal of Management*, *1*(1), 51-64.

Johansson, G., & Winroth, M. (2009, June). Lean vs. Green manufacturing: Similarities and differences. In *Proceedings of the 16th International Annual EurOMA Conference, Implementation Realizing Operations Management Knowledge, Göteborg, Sweden*.

Jolley CE (2004). Performance Transformation: Utilizing lean and six sigma. McKinsey and Company, Cleveland, Ohio.

Jonsson, P., Andersson, D., Arlbjørn, J. S., Freytag, P. V., & de Haas, H. (2011). Service supply chain management. *International Journal of Physical Distribution & Logistics Management*, *41*, 277-295.

Juran, J. M., & Godfrey, A. B. (1999). *Juran's Quality Handbook*, McGraw-Hill.

Kadam, S. J., Shende, P. N., & Kamble, P. D. (2012). Value stream mapping tool for waste identification in tyre-rim assembly of tractor manufacturing. In *International Conference on Emerging Frontiers in Technology for Rural Area (EFITRA) 2012, Proceedings published in International Journal of Computer Applications* (pp. 6-8).

Kannan, V. R., & Tan, K. C. (2005). Just in time, total quality management, and supply chain management: understanding their linkages and impact on business performance. *Omega*, *33*(2), 153-162.

Kanyanya, O. C. (2013). *Lean Manufacturing Practices and Performance of Organizations listed at the Nairobi Securities Exchange* (Doctoral dissertation, University of Nairobi).

Karim, M. A., Smith, A. J. R., Halgamuge, S. K., & Islam, M. M. (2008). A comparative study of manufacturing practices and performance variables. *International Journal of Production Economics*, *112*(2), 841-859.

Karlsson, C., & Åhlström, P. (1996). Assessing changes towards lean production. *International Journal of Operations & Production Management*, Vol. 16, pp.24–41.

Kaswan, M. S., & Rathi, R. (2019). Analysis and modeling the enablers of green lean six sigma implementation using interpretive structural modeling. *Journal of cleaner production*, *231*, 1182-1191.

Kayanda, A. (2017). Analysis of Supply Chains in The Recycling Of Electronic Waste.: Resource efficiency within recycling supply chains.

Kaymakçı, Ö. (2012). Bir PTT Şubesinde Yalın Üretim-5S Uygulaması. *Sakarya Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi*, *79*.

Kazmane, J. (2018). Proposal and Analysis of a Model for Design and Development of Lean Supply Chain Strategy. In *International Journal of Engineering Research in Africa* (Vol. 37, pp. 158-171). Trans Tech Publications Ltd.

Kennedy, I., Plunkett, A., & Haider, J. (2013). Implementation of lean principles in a food manufacturing company. In *Advances in sustainable and competitive manufacturing systems* (pp. 1579-1590). Springer, Heidelberg.

Keyte, B., & Locher, D. A. (2004). *The complete lean enterprise: Value stream mapping for administrative and office processes*. CRC Press.

Kılıç, A. & Ayvaz, B. (2016). Türkiye Otomotiv Yan Sanayinde Yalın Üretim Uygulaması. *İstanbul Ticaret Üniversitesi Fen Bilimleri Dergisi, 15*(29), 29-60.

Kimani, M. W. (2013). *Lean Supply Chain Management in Manufacturing Firms in Kenya* (Doctoral dissertation, University of Nairobi).

King, A. A., & Lenox, M. J. (2001). Lean and green? An empirical examination of the relationship between lean production and environmental performance. *Production and operations management, 10*(3), 244-256.

Knechtges, P., & Decker, M. C. (2014). Application of kaizen methodology to foster departmental engagement in quality improvement. *Journal of the American college of radiology, 11*(12), 1126-1130.

Ko, C.H. & Chung, N.F. (2014), "Lean design process", *Journal of Construction Engineering and Management,* Vol. 4 No. 3, pp. 464-468.

Kobayashi, I. (1995). *Twenty Keys to Workplace Improvement,* Productivity Press, Cambridge, MA.

Kobu, B. (2003). Üretim Yönetimi, Avcıol Basım Yayın, İstanbul. *C*, *13*, 3.

Koskela, L. (1992). *Application of the new production philosophy to construction* (Vol. 72). Stanford: Stanford university.

Koskela, L., Bølviken, T., & Rooke, J. (2013). Which are the wastes of construction?, *Proceedings of the 21st Annual Conference of the International Group for Lean Construction, Fortaleza, August*, pp. 3-12.

Košturiak, J., & Frolík, Z. (2006). *Štíhlý a inovativní podnik* (Vol. 1). Alfa publishing.

Köksal, Mustafa. (2007). *Bakım Planlaması,* Seçkin Yayıncılık San. ve Tic. A.Ş, Ankara.

Krafcik, J. F. (1988). Triumph of the lean production system. *MIT Sloan Management Review, 30*(1), 41.

Krajevski, L, J., Ritzman, L. P., & Malhotra, M. K. (2007). *Operations Management*: Pearson Prentice Hall, New Jersey.

Kucerova, M., Mlkva, M., Sablik, J., & Gejgus, M. (2015). Eliminating waste in the production process using tools and methods of industrial engineering. *Production Engineering Archives*, *9*(4), 30-34.

Kumar Singh, R., & Modgil, S. (2020). Assessment of Lean Supply Chain Practices in Indian Automotive Industry. *Global Business Review*, 0972150919890234.

Kumar, C. S., & Panneerselvam, R. (2007). Literature review of JIT-KANBAN system. *The International Journal of Advanced Manufacturing Technology*, *32*(3-4), 393-408.

Kumar, M., & Vaishya, R. (2018). Real-time monitoring system to lean manufacturing. *Procedia Manufacturing*, *20*, 135-140.

Kumar, V., & Bajaj, A. (2015). The Implementation of Single Minute Exchange of Die with 5 S in Machining Processes for reduction of Setup Time. *International Journal on Recent Technologies in Mechanical and Electrical Engineering*, *2*(2), 32-39.

Kurdve, M., Shahbazi, S., Wendin, M., Bengtsson, C., & Wiktorsson, M. (2015). Waste flow mapping to improve sustainability of waste management: a case study approach. *Journal of Cleaner Production*, *98*, 304-315.

Larson, T., & Greenwood, R. (2004). Perfect complements: synergies between lean production and eco-sustainability initiatives. *Environmental Quality Management*, *13*(4), 27-36.

Lean Aerospace Initiative. (1998). "Seven Information Wastes." *Output from LAI Product Development Workshop*. Los Angeles.

Lean Enterprise Institute. (2018). What Is Lean? LEI. Retrieved 8 December from http://www.lean.org/whatslean.

Levinson, W. A., & Rerick, R. A. (2002). *Lean enterprise: A synergistic approach to minimizing waste*. Asq Press.

Levy, D. L. (1997). Lean production in an International Supply Chain, *Sloan Management Review*, 94-102.

Lewis, M. (2000). Lean production and sustainable competitive advantage. *International Journal of Operations & Production Management*, *20*(8), 2–14.

Li, H., Chen, Z., Yong, L., & Kong, S. C. (2005). Application of integrated GPS and GIS technology for reducing construction waste and improving construction efficiency. *Automation in Construction*, *14*(3), 323-331.

Lian, Y. H., & Van Landeghem, H. (2002, October). An application of simulation and value stream mapping in lean manufacturing. In *Proceedings 14th European Simulation Symposium* (pp. 1-8). c) SCS Europe BVBA.

Liker KJ. (1998). Becoming Lean. Portland, Oregon: Productivity Press.

Liker, J. K. (2004). *Toyota way: 14 management principles from the world's greatest manufacturer*. McGraw-Hill Education.

Liker, J. K., & Lamb, T. (2000). *Lean Manufacturing Principles Guide, Version 0.5. A Guide to Lean Shipbuilding* (No. ASE-PROJECT-10). MICHIGAN UNIV ANN ARBOR.

Lin, C. J., Chen, F. F., & Chen, Y. M. (2013). Knowledge kanban system for virtual research and development. *Robotics and Computer-Integrated Manufacturing*, *29*(3), 119-134.

Liu, S., Leat, M., Moizer, J., Megicks, P., & Kasturiratne, D. (2013). A decision-focused knowledge management framework to support collaborative decision making for lean supply chain management. *International Journal of Production Research*, *51*(7), 2123-2137.

Mangan, J., Lalwani, C. & Butcher, T. (2008). *Global logistics and supply chain management,* John Wiley & Sons.

Mann, D. (2009). The missing link: Lean leadership. *Frontiers of health services management*, *26*(1), 15-26.

Marchwinski, C., Shook, J., & Schroeder, A. (2011). *Yalın Kavramlar Sözlüğü. Yalın Düşünürler için Şekilli Sözlük.* Derleyen: Lean Enterprise Institute, ABD, (Çeviren: Soydan, A. & Baran, R.), Optimist Yayın No. 247, İstanbul: Optimist Yayınları

Marodin, G. A., & Saurin, T. A. (2013). Implementing lean production systems: research areas and opportunities for future studies. *International Journal of Production Research*, *51*(22), 6663-6680.

Marodin, G. A., Frank, A. G., Tortorella, G. L., & Saurin, T. A. (2016). Contextual factors and lean production implementation in the Brazilian automotive supply chain. *Supply Chain Management: An International Journal*, *21*, 417-432.

Marodin, G. A., Tortorella, G. L., Frank, A. G., & Godinho Filho, M. (2017). The moderating effect of Lean supply chain management on the impact of Lean shop floor practices on quality and inventory. *Supply Chain Management: An International Journal*, *22*(6), 473-485.

Marodin, G., Frank, A. G., Tortorella, G. L., & Netland, T. (2018). Lean product development and lean manufacturing: Testing moderation effects. *International Journal of Production Economics, 203*, 301-310.

Martínez-Jurado, P. J., & Moyano-Fuentes, J. (2014). Lean management, supply chain management and sustainability: a literature review. *Journal of Cleaner Production*, *85*, 134-150.

Mascitelli, R. (2007). *The lean product development guidebook: everything your design team needs to improve efficiency and slash time-to-market*. Technology Perspectives.

Mascitelli, R. (2011). *Mastering lean product development: A practical, event-driven process for maximizing speed, profits and quality*. Technology Perspectives.

Mason-Jones, R., Naylor, B., & Towill, D. R. (2000). Engineering the leagile supply chain. *International journal of agile management systems*, 2(1), 54-61.

Maxime, D., Marcotte, M., & Arcand, Y. (2006). Development of eco-efficiency indicators for the Canadian food and beverage industry. *Journal of Cleaner Production*, *14*(6-7), 636-648.

McManus, H. L. (2005). Product Development Value Stream Mapping (PDVSM) Manual Release 1.0.

Mears, P. (1995). *Quality improvement tools & techniques*. McGraw-Hill.

Melnyk, S. A., Sroufe, R. P., & Calantone, R. (2003). Assessing the impact of environmental management systems on corporate and environmental performance. *Journal of operations management*, *21*(3), 329-351.

Melton, T. (2005). The benefits of lean manufacturing: what lean thinking has to offer the process industries. *Chemical engineering research and design*, *83*(6), 662-673.

Meng, X. (2019). Lean management in the context of construction supply chains. *International Journal of Production Research*, *57*(11), 3784-3798.

Michlowicz, E., & Smolińska, K. (2014). Metoda TPM jako element poprawy ciągłości przepływu. *Logistyka*, *3*(1), 4330-4337.

Mike, R., & Rick, H. (2001). Sürekli Akış Yaratmak, çev. *Kulaç Ülki., Yalın Enstitü Derneği, The Lean Enterprise Institute, İstanbul*.

Miles, L. D. (1961). Handwritten graph, untitled, undated. From filing context, appears to illustrate book sales for" Techniques of Value Analysis and Engineering" textbook published by McGraw-Hill.--Graphic Design.

Miller, G., Pawloski, J., & Standridge, C. R. (2010). A case study of lean, sustainable manufacturing. *Journal of Industrial Engineering and Management (JIEM)*, *3*(1), 11-32.

Minh, N. D., Nguyen, N. D., & Cuong, P. K. (2019). Applying lean tools and principles to reduce cost of waste management: an empirical research in Vietnam. *Management and Production Engineering Review*, *10*.

MĺKva, M., Kučerová, M., & Večeřa, P. (2012). Application of tools and methods within" Lean manufacturing. In *Carpathian Logistics Congress* (p. 6).

Monden, Y. (1993). *Toyota Production System: An Integrated Approach to Just-In-Time*, Engineering&Management Press, Second Edition, Georgia.

Monden, Y. (1998). *Toyota Production System. An Integrated Approach to Just-In-Time*, 3rd ed., Engineering & Management Press, Norcross, GA.

Monden, Y. (2011). *Toyota production system: an integrated approach to just-in-time*. CRc Press.

Monden, Y., & Minagawa, Y. (2016). Lean management of global supply chain. New Jersey: World Scientific

Mostafa, S., & Dumrak, J. (2015). Waste elimination for manufacturing sustainability. *Procedia manufacturing*, *2*, 11-16.

Mostafa, S., Dumrak, J., & Soltan, H. (2013). A framework for lean manufacturing implementation. *Production & Manufacturing Research*, *1*(1), 44-64.

Mou, Q., Xu, Z., & Liao, H. (2016). An intuitionistic fuzzy multiplicative best-worst method for multi-criteria group decision making. *Information Sciences*, *374*, 224-239.

Murman, E., Allen, T., Bozdogan, K., Cutcher-Gershenfeld, J., McManus, H., Nightingale, D., ... & Widnall, S. (2002). Lean Enterprises. In *Lean Enterprise Value* (pp. 142-174). Palgrave Macmillan, London.

Murphy, S., & Pincetl, S. (2013). Zero waste in Los Angeles: Is the emperor wearing any clothes?. *Resources, Conservation and Recycling*, *81*, 40-51.

Musee, N., Lorenzen, L., & Aldrich, C. (2007). Cellar waste minimization in the wine industry: a systems approach. *Journal of Cleaner Production*, *15*(5), 417-431.

Myerson, P. (2012). *Lean supply chain and logistics management*. McGraw-Hill Education.

Narasimhan, R., Swink, M., & Kim, S. W. (2006). Disentangling leanness and agility: an empirical investigation. *Journal of operations management*, *24*(5), 440-457.

Nasab, H. H., & Zare, H. K. (2012). Finding a probabilistic approach to analyze lean manufacturing. *Journal of Cleaner Production*, *29*, 73-81.

Nash, M. A., & Poling, S. R. (2011). *Mapping the total value stream: a comprehensive guide for production and transactional processes*. CRC Press.

Naylor, J. B., Naim, M. M., & Berry, D. (1999). Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain. *International Journal of production economics*, *62*(1-2), 107-118.

Negrão, L. L. L., Godinho Filho, M., & Marodin, G. (2017). Lean practices and their effect on performance: a literature review. *Production Planning & Control*, *28*(1), 33-56.

Netland, T. H., & Sanchez, E. (2014). Effects of a production improvement programme on global quality performance. *The TQM journal*, *26*(2), 188-201.

Niederstadt J. (2014). *Kamishibai Boards: A Lean Visual Management System That Supports Layered Audits,* CRC Press.

Nordin, N., Deros, B. M., & Abd Wahab, D. (2010). A survey on lean manufacturing implementation in Malaysian automotive industry. *International Journal of Innovation, Management and Technology*, *1*(4), 374.

Oehmen, J., & Rebentisch, E. (2010). *Waste in lean product development*. Lean Advancement Initiative.

Ohno, T. (1988). *Toyota production system: beyond large-scale production*. crc Press.

Ohno, T. (1998). *Toyoto production system,* New York, Productivity Press.

Ohno, T., & Paridudin, M. S. (2010). *Sistem Pengeluaran Toyota: Melangkaui Pengeluaran Skala Besar*. Move Associations.

Oko, A. (2016). Lean Supply Chain Management; Its Prospect for a Depressed Economy Like Nigeria. *International Journal of Advanced Engineering, Management and Science*, *2*(12), 239720.

Okur, A. S. (1997). *Yalın üretim: 2000'li yıllara doğru Türkiye sanayii için yapılanma modeli*. Söz Yayın.

Olesen, P., Powell, D., Hvolby, H. H., & Fraser, K. (2015). Using lean principles to drive operational improvements in intermodal container facilities. *Journal of Facilities Management*, *13*(3), 266-281.

Oliver, N., Schab, L., & Holweg, M. (2007). Lean principles and premium brands: conflict or complement?. *International journal of production research*, *45*(16), 3723-3739.

Org, A., Grossmeier, J., Fabius, R., Flynn, J. P., Noeldner, S. P., Fabius, D., ... & Anderson, D. R. (2016). Linking Workplace Health Promotion Best Practices and Organizational Financial Performance Scores on the HERO Scorecard.

Ortiz, C. (2006). All-Out Kaizen *IIE Solutions Journal, 38*(4), 21-30.

Osmani, M. (2011). "Construction waste", in Letcher, T.M. and Vallero, D.A. (Eds), *Waste: A Handbook for Management,* Academic Press, Loughborough University, pp. 207-218.

Osmani, M., Glass, J., & Price, A. D. (2008). Architects' perspectives on construction waste reduction by design. *Waste management*, *28*(7), 1147-1158.

Öksüz, M. K., Öner, M., & Öner, S. C. (2017). Yalin Üretim Tekniklerinin Endüstri 4.0 Perspektifinden Değerlendirilmesi. *Uluslararası Bölgesel Kalkınma Konferansı*.

Özçelik, T. Ö., & Cinoğlu, F. (2013). Yalin Felsefe Ve Bir Otomotiv Yan Sanayi Uygulamasi. *İstanbul Ticaret Üniversitesi Fen Bilimleri Dergisi*, *12*(23), 79-101.

Özkan, O., Bayın, G., & Yeşilaydın, G. (2015). Sağlık Sektöründe Yalın Tedarik Zinciri Yönetimi. *Online Academic Journal of Information Technology*, *6*(18), 71-93.

Pacheco, D., Pergher, I., Vaccaro, G.L.R., Jung, C.F. & ten Caten, C. (2015). 18 comparative aspects between lean and Six Sigma: complementarity and implications, *International Journal of Lean Six Sigma*, *6*(2), 161-175.

Page, J. (2004). Implementing Lean Manufacturing Techniques Gardner Publications. *Ohio, USA.*

Pakdil, F., & Leonard, K. M. (2014). Criteria for a lean organisation: development of a lean assessment tool. *International Journal of Production Research*, *52*(15), 4587-4607.

Pampanelli, A. B., Found, P., & Bernardes, A. M. (2014). A Lean & Green Model for a production cell. *Journal of cleaner production*, *85*, 19-30.

Pamučar, D., Ecer, F., Cirovic, G., & Arlasheedi, M. A. (2020). Application of improved best worst method (BWM) in real-world problems. *Mathematics*, *8*(8), 1342.

Paranitharan, K. P., Begam, M. S., Abuthakeer, S. S., & Subha, M. V. (2011). Redesinging an automotive assembly line through lean strategy. *International Journal of Lean Thinking*, *2*(2), 1-14.

Paredes, M., Villa, J., Quispe, G., Raymundo, C., & Moguerza, J. M. (2018). Lean Manufacturing model for the improvement of manufacturing processes in small and medium-sized companies in the furniture industrial sector. In *CISCI 2018-Decima Septima Conferencia Iberoamericana en Sistemas, Cibernetica e Informatica, Decimo Quinto Simposium Iberoamericano en Educacion, Cibernetica e Informatica, SIECI 2018-Memorias* (Vol. 1, pp. 46-51).

Pattanaik, L. N., & Sharma, B. P. (2009). Implementing lean manufacturing with cellular layout: a case study. *The International Journal of Advanced Manufacturing Technology*, *42*(7-8), 772-779.

Pavnaskar, S. J., Gershenson, J. K., & Jambekar, A. B. (2003). Classification scheme for lean manufacturing tools. *International journal of production research*, *41*(13), 3075-3090.

Pekin, E., & Çil, İ. (2015). Kauçuk sektörü Poka-Yoke uygulaması. *Sakarya Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *19*(2), 163-170.

Perez, C., de Castro, R., Simons, D., & Gimenez, G. (2010). Development of lean supply chains: a case study of the Catalan pork sector. *Supply Chain Management: An International Journal*, *15*, 55-68.

Pessôa, M. V. P. (2008). Weaving the waste net: a model to the product development system low performance drivers and its causes. *LAI White Paper, Cambridge*.

Pieńkowski, M. (2014). Waste measurement techniques for lean companies. *International Journal of Lean Thinking*, *5*(1), 9-24.

Prajapati, M. R., & Deshpande, V. (2015). Cycle time reduction using lean principles and techniques: A review. *Journal, International Engineering, Industrial*, *3*(4), 208-213.

Prasad, S., Khanduja, D., & Sharma, S. K. (2018). A study on implementation of lean manufacturing in Indian foundry industry by analysing lean waste issues. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *232*(2), 371-378.

Prasetyawan, Y., & Ibrahim, N. G. (2020, April). Warehouse Improvement Evaluation using Lean Warehousing Approach and Linear Programming. In *IOP Conference Series: Materials Science and Engineering* (Vol. 847, No. 1, p. 012033). IOP Publishing.

Puvanasvaran, A. P., Muhamad, M. R., Megat, M. H. M. A., Tang, S. H., & Hamouda, A. M. S. (2008). *A review of problem solving capabilities in lean process management*, *5*, 504-511.

Rahman, N. A. A., Sharif, S. M., & Esa, M. M. (2013). Lean manufacturing case study with Kanban system implementation. *Procedia Economics and Finance*, *7*, 174-180.

Rai, R., Sahoo, G., & Mehfuz, S. (2015). Exploring the factors influencing the cloud computing adoption: a systematic study on cloud migration. *SpringerPlus*, *4*(1), 197.

Raman, S. (1998). Lean software development: is it feasible?. In *17th dasc. aiaa/ieee/sae. digital avionics systems conference. proceedings (cat. no. 98ch36267)* (Vol. 1, pp. C13-1). IEEE.

Ramaswamy, N. R., Selladurai, V., & Gunasekaran, A. (2002). Just-in-time implementation in small and medium enterprises. *Work Study*, *51*(2), 85-90.

Rawabdeh, I. A. (2005). A model for the assessment of waste in job shop environments. *International Journal of Operations & Production Management*, *25*(8), 800-822.

Ren, J., Liang, H., & Chan, F. T. (2017). Urban sewage sludge, sustainability, and transition for Eco-City: Multi-criteria sustainability assessment of technologies based on best-worst method. *Technological Forecasting and Social Change*, *116*, 29-39.

Rewers, P., Trojanowska, J., & Chabowski, P. (2016). „Tools and methods of Lean Manufacturing-a literature review.“. In *7th International Technical Conference TECHNOLOGICAL FORUM* (pp. 135-139).

Rezaei, J. (2015). Best-worst multi-criteria decision-making method. *Omega*, *53*, 49-57.

Rezaei, J. (2016). Best-worst multi-criteria decision-making method: Some properties and a linear model. *Omega*, *64*, 126-130.

Rezaei, J. (2020). A concentration ratio for nonlinear best worst method. *International Journal of Information Technology & Decision Making*, *19*(03), 891-907.

Rezaei, J., Nispeling, T., Sarkis, J., & Tavasszy, L. (2016). A supplier selection life cycle approach integrating traditional and environmental criteria using the best worst method. *Journal of Cleaner Production*, *135*, 577-588.

Richen, A., & Steinhorst, A. (2005). Standardization or harmonization? you need both. *European Health Informatics (November 2005)*, *5*.

Ringen, G., Aschehoug, S. H., Holtskog, H., & Ingvaldsen, J. A. (2014). Integrating quality and lean into a holistic production system, *Procedia CIRP*, *17*, 242–247.

Romero, D., Gaiardelli, P., Thürer, M., Powell, D., & Wuest, T. (2019, September). Cyber-Physical Waste Identification and Elimination Strategies in the Digital Lean Manufacturing World. In *IFIP International Conference on Advances in Production Management Systems* (pp. 37-45). Springer, Cham.

Rossini, M., & Staudacher, A. P. (2016). Lean supply chain planning: A performance evaluation through simulation. In *MATEC Web of Conferences* (Vol. 81, p. 06002). EDP Sciences.

Rothenberg, S., Pil, F. K., & Maxwell, J. (2001). Lean, green, and the quest for superior environmental performance. *Production and operations management*, *10*(3), 228-243.

Rother, M. & Shook, J. (2009). *Learning to See: Value Stream Mapping to Create Value and Eliminate Muda*, The Lean Enterprise Institute, Brookline, MA.

Rother, M., & Shook, J. O. H. N. (1999). Görmeyi öğrenmek. *Brookline: The Lean Enterprise Institute*.

Russel, R. S & Taylor, B. W. (1999). *Operations management.* 2nd ed.Upper Saddle River, NJ; New York: Prentice Hall.

Russel, R. S., & Taylor, B. W. (1998). *Operations Management,* Prentice Hall, Second Edition, New Jersey.

Rymaszewska, A. D. (2014). The challenges of lean manufacturing implementation in SMEs. *Benchmarking: An International Journal*, *21*(6), 987-1002.

Sadaghiani, S., Ahmad, K. W., Rezaei, J., & Tavasszy, L. (2015, April). Evaluation of external forces affecting supply chain sustainability in oil and gas industry using Best Worst Method. In *2015 International Mediterranean Gas and Oil Conference (MedGO)* (pp. 1-4). IEEE.

Sadjadi, S., & Karimi, M. (2018). Best-worst multi-criteria decision-making method: A robust approach. *Decision Science Letters*, *7*(4), 323-340.

Safarzadeh, S., Khansefid, S., & Rasti-Barzoki, M. (2018). A group multi-criteria decision-making based on best-worst method. *Computers & Industrial Engineering*, *126*, 111-121.

Saleh, C., Mubiena, G. F., Immawan, T., & Hassan, A. (2016, February). Lean production in improving supply chain performance through hybrid model SCOR 11.0-system dynamics. In *IOP Conference Series: Materials Science and Engineering* (Vol. 114, No. 1, p. 012069). IOP Publishing.

Salimi, N., & Rezaei, J. (2016). Measuring efficiency of university-industry Ph. D. projects using best worst method. *Scientometrics*, *109*(3), 1911-1938.

Salo, A. A., & Hämäläinen, R. P. (1997). On the measurement of preferences in the analytic hierarchy process. *Journal of Multi-Criteria Decision Analysis*, *6*(6), 309-319.

Saudi, M. H. M., Juniati, S., Kozicka, K., & Razimi, M. S. A. (2019). Influence of lean practices on supply chain performance. *Polish Journal of Management Studies*, *19*.

Savaş, H., & Kılıç, İ. (2013). Yalın Lojistik Açısından Konaklama İşletmelerinin Tedarik Zinciri Yapısı Ve Karşılaştırmalı Bir Maliyet Analizi. *Anemon Muş Alparslan Üniversitesi Sosyal Bilimler Dergisi*, *1*(1), 191-220.

Sayer N. J., & Williams, B. (2007). *Lean for Dummies*, Wiley Publishing.

Schemenner, R, W. (1993). *Production/operations Management*, Prentice-Hall Fifth Ed., New Jersey.

Schmenner, R. W., & Vastag, G. (2006). Revisiting the theory of production competence: extensions and cross-validations. *Journal of Operations Management*, *24*(6), 893-909.

Schmenner, R. W., Van Wassenhove, L., Ketokivi, M., Heyl, J., & Lusch, R. F. (2009). Too much theory, not enough understanding⋆. *Journal of Operations Management*, *27*(5), 339-343.

Schniederjans, M. J. (1993). *Topics in Just-in-time Management*. Allyn & Bacon.

Schonberger, R. J. (1982). *Japanese manufacturing techniques: Nine hidden lessons in simplicity*. Free Press, New York.

Schroeder, D. M., & Robinson, A. G. (2010). Green is free. *Organizational Dynamics*, *4*(39), 345-352.

Selvi, K., & Majumdar, R. (2014). Six sigma-overview of DMAIC and DMADV. *International Journal of Innovative Science and Modern Engineering*, *2*(5), 16-19.

Shaaban, S., Darwish, A. S., BR, R. K., Sharma, M. K., & Agarwal, A. (2015). An experimental investigation of lean management in aviation. *Journal of Manufacturing Technology Management*.

Shah, B., & Khanzode, V. (2017). Storage allocation framework for designing lean buffers in forward-reserve model: a test case. *International Journal of Retail & Distribution Management*, *45*(1), 90-118.

Shah, R., & Ward, P. T. (2003). Lean manufacturing: context, practice bundles, and performance. *Journal of operations management*, *21*(2), 129-149.

Shah, R., & Ward, P. T. (2007). Defining and developing measures of lean production. *Journal of operations management*, *25*(4), 785-805.

Shah, S. R., & Ganji, E. N. (2017). Lean production and supply chain innovation in baked foods supplier to improve performance. *British Food Journal*.

Shaikh, M. R., Asim, D. M., & Manzoor, S. (2020). Effective Warehouse Management Using Lean Concepts And its Effects on Pakistan's Fmcg Industry. *CenRaPS Journal of Social Sciences*, *2*(1), 167-177.

Shehadeh, R., Al-Zu'bi, Z. M. F., Abdallah, A. B., & Maqableh, M. (2016). Investigating critical factors affecting the operational excellence of service firms in Jordan. *Journal of Management Research*, *8*(1), 18-49.

Sheikh Sha Alam, D., Ahmed, E. M., Shiddique, N. A., Siddik, A. B., Prianka, S. R., & Aktar, R. (2019). Reduction of wastage and improvement of productivity through lean thinking. *International Journal of Research in Advanced Engineering and Technology*, *5*(3), 104-110.

Shingo, S. (1989). *A Study of the Toyota Production System from an Industrial Engineering Viewpoint,* Revised ed., Productivity Press, Cambridge, MA.

Shingo, S., & Dillon, A. P. (1989). *A study of the Toyota production system: From an Industrial Engineering Viewpoint*. CRC Press.

Shivanand, H. K. (2006). *Flexible manufacturing system*. New Age International.

Shou, W., Wang, J., Wu, P., & Wang, X. (2020). Value adding and non-value adding activities in turnaround maintenance process: classification, validation, and benefits. *Production Planning & Control*, *31*(1), 60-77.

Siasos, G. I., Skondras, G. I., Gkanas, E., Hrissagis, K., & Makridis, S. S. (2017). The benefits of Lean through an analysis and improvement of an existing production line. *Mater. Sci. Eng. Adv. Res*, *2*(1), 15-24.

Simpson, D. F., & Power, D. J. (2005). Use the supply relationship to develop lean and green suppliers. *Supply chain management: An international Journal*.

Singh, B., Garg, S. K., & Sharma, S. K. (2011). Value stream mapping: literature review and implications for Indian industry. *The International Journal of Advanced Manufacturing Technology*, *53*(5-8), 799-809.

Singh, B., Garg, S. K., Sharma, S. K., & Grewal, C. (2010). Lean implementation and its benefits to production industry. *International journal of lean six sigma*, *1*, 157-168.

Singh, J., & Singh, H. (2009). Kaizen philosophy: a review of literature. *IUP journal of operations management*, *8*(2), 51-72.

Sirshar, M., Hanif, I., Shahzad, S., & Khalid, M. (2019). A Review Paper on Simulation Based Six Sigma Approach in Quality Assurance.

Skinner, D. (2003). Lean and Clean. *A Better Way to Run Sheet Metal Shops, Books Say Snips. Troy*, *72*(7), 48-56.

Slack, R. A. (1999). *The lean value principle in military aerospace product development*.

Smith, R., & Hawkins, B. (2004). *Lean maintenance: reduce costs, improve quality, and increase market share*. Elsevier.

So, S., & Sun, H. (2011). An extension of IDT in examining the relationship between electronic-enabled supply chain integration and the adoption of lean production. *International Journal of Production Research*, *49*(2), 447-466.

Soltan, H., & Mostafa, S. (2015). Lean and agile performance framework for manufacturing enterprises. *Procedia Manufacturing*, *2*, 476-484.

Spear, S. J. (2004). Learning to lead at Toyota. *Harvard business review*, *82*(5), 78-91.

Stanke, A. K. (2001). *A framework for achieving lifecycle value in product development* (Doctoral dissertation, Massachusetts Institute of Technology).

Stevenson, W, J. (1993). *Production/Operations Management*, IRWIN.

Stone, K. B. (2012). Four decades of lean: a systematic literature review. *International Journal of Lean Six Sigma*.

Stone, K. B. (2012). International Journal of Lean Six Sigma. *Sigma*, *3*(2), 112-132.

Sugimori, Y., Kusunoki, K., Cho, F., & UCHIKAWA, S. (1977). Toyota production system and kanban system materialization of just-in-time and respect-for-human system. *The international journal of production research*, *15*(6), 553-564.

Sugimori, Y., Kusunoki, K., Cho, F., & UCHIKAWA, S. (1977). Toyota production system and kanban system materialization of just-in-time and respect-for-human system. *The international journal of production research*, *15*(6), 553-564.

Sukwadi, R., Wee, H. M., & Yang, C. C. (2013). Supply chain performance based on the lean–agile operations and supplier–firm partnership: An empirical study on the garment industry in Indonesia. *Journal of Small Business Management*, *51*(2), 297-311.

Sultanov, F., & Özçakar, D. N. Yalın Tedarik Zincirinde Optimizasyon.

Sundar, R., Balaji, A.N., & Kumar, R. M. S. (2014). A review on lean manufacturing implementation techniques. *Procedia Engineering*, *97*(1), 1875–1885.

Sutrisno, A., Vanany, I., Gunawan, I., & Asjad, M. (2018, April). Lean waste classification model to support the sustainable operational practice. In *IOP Conference Series: Materials Sciences and Engineering* (Vol. 337, p. 012067).

Suzaki, K. (1993). *New shop floor management: empowering people for continuous improvement*. Simon and Schuster.

Swamidass, P. M. (2000). *Encyclopedia of production and manufacturing management.* Kluwer Academic Publishers.

Şahin, Ş. (2009). *Fokus grup yöntemine yönelik reklam ajansı ve araştırma şirketlerinin tutumu* (Doctoral dissertation, Sosyal Bilimler Enstitisü.

T.C. Tarım Ve Orman Bakanlığı. (2021). Retrieved 15 March 2021, from https://www.tarimorman.gov.tr/

Tanık, M. (2010). Kalıp Ayar Sürelerinin SMED Metodolojisi ile İyileştirilmesi: Bir Yalın Altı Sigma Uygulaması. *Muğla Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *25*, 118-140.

Tarım Ürünleri Piyasaları. (2021). Retrieved 15 March 2021, from https://arastirma.tarimorman.gov.tr/tepge/Menu/27/Tarim-Urunleri-Piyasalari

Tekin, M. (1999). *Üretim Yönetimi,* Arı Ofset Matbaacılık, Cilt 2, Konya.

Thangarajoo, Y., & Smith, A. (2015). Lean thinking: An overview. *Industrial Engineering & Management,[e-journal]*, *4*(2), 1000159.

Thompson, D., & Mintz, P. (1999). Lean manufacturing. *The Business Journal, http://www. citec. org/lean_manufacturing. html, December, 15*.

Thurston, J., & Ulmer, J. M. (2016). The Principles of Lean Manufacturing. *Franklin Business & Law Journal*, *2016*(2).

Thürer, M., Tomašević, I., & Stevenson, M. (2017). On the meaning of 'waste': review and definition. *Production Planning & Control*, *28*(3), 244-255.

Todd, P. (2000). Lean manufacturing: building the lean machine. *Journal of Advanced Manufacturing*, *12*, 1-12.

Tomašević, I., & Slović, D. (2013). Facilitating wasteful activities discovery in pure service environment through usage of process mining. *International Journal of Industrial Engineering and Management*, *4*(4), 199-206.

Top, A. (2001). Üretim Sistemleri Analiz, Planlama ve Kontrolü. *İstanbul: Alfa Basım, Yayım, Dağıtım Ltd. Şti*.

Tortorella, G. L., Miorando, R., & Marodin, G. (2017). Lean supply chain management: Empirical research on practices, contexts and performance. *International Journal of Production Economics*, *193*, 98-112.

Tran, H. (2016). Improving Warehousing process with Lean Management.

Trojanowska, J., Kolińska, K., & Koliński, A. (2011). Stosowanie narzędzi Lean w przedsiębiorstwach produkcyjnych jako skuteczny sposób walki z kryzysem gospodarczym. *Problemy zarządzania*, (1/2011 (31)), 34-52.

TÜİK - Veri Portalı. (2021). Retrieved 15 March 2021, from https://data.tuik.gov.tr

Türkiye Gıda ve İçecek Sektörleri Dış Ticaret Verileri – TGDF. (2021). Retrieved 15 March 2021, from https://www.tgdf.org.tr/turkiye-gida-ve-icecek-sektorleri-dis-ticaret-verileri

TÜSİAD. (2020). TÜSİAD Tarım ve Gıda 2020 Özet Raporu. Retrieved 15 March 2021, from https://tusiad.org/tr

Vanichchinchai, A. (2019). Exploring organizational contexts on lean manufacturing and supply chain relationship. *Journal of Manufacturing Technology Management*, *31*(2), 236-259.

Veres, C., Marian, L., Moica, S., & Al-Akel, K. (2018). Case study concerning 5S method impact in an automotive company. *Procedia Manufacturing*, *22*, 900-905.

Verrier, B., Rose, B., Caillaud, E., & Remita, H. (2014). Combining organizational performance with sustainable development issues: the Lean and Green project benchmarking repository. *Journal of Cleaner Production*, *85*, 83-93.

Villarreal, B., Garza-Reyes, J. A., & Kumar, V. (2016). Lean road transportation–a systematic method for the improvement of road transport operations. *Production Planning & Control*, *27*(11), 865-877.

Vinodh, S., Arvind, K. R., & Somanaathan, M. (2011). Tools and techniques for enabling sustainability through lean initiatives. *Clean Technologies and Environmental Policy*, *13*(3), 469-479.

Wahab, A. N. A., Mukhtar, M., & Sulaiman, R. (2013). A conceptual model of lean manufacturing dimensions. *Procedia Technology*, *11*, 1292-1298.

Waller, D. L. (2003). *Operations Management: A Supply Chain Approach*, Thompson, London.

Wang, S., & Ye, B. (2018). A comparison between just-in-time and economic order quantity models with carbon emissions. *Journal of Cleaner Production*, *187*, 662-671.

Waring, J. J., & Bishop, S. (2010). Lean healthcare: rhetoric, ritual and resistance. *Social science & medicine*, *71*(7), 1332-1340.

Waters, D. (2008). *Inventory control and management*. John Wiley & Sons.

Wee, H. M., & Wu, S. (2009). Lean supply chain and its effect on product cost and quality: a case study on Ford Motor Company. *Supply Chain Management: An International Journal*, *14*(5), 335-341.

Welo, T., & Ringen, G. (2016). Beyond waste elimination: Assessing lean practices in product development. *Procedia CIRP*, *50*(2016), 179-185.

Wickramasinghe, G. L. D., & Wickramasinghe, V. (2017). Implementation of lean production practices and manufacturing performance. *Journal of Manufacturing Technology Management*, *28*, 531-550.

Wiese, A., Luke, R., Heyns, G. J., & Pisa, N. M. (2015). The integration of lean, green and best practice business principles. *Journal of Transport and Supply Chain Management*, *9*(1), 1-10.

Witcher, B. J., & Butterworth, R. (2001). Hoshin Kanri: policy management in Japanese-owned UK subsidiaries. *Journal of Management Studies*, *38*(5), 651-674.

Womack James, P., & Jones Daniel, T. (1998). Yalın Düşünce, çev. *Aras Nesime, Sistem Yayıncılık ve MAt. San. Tic. A. Ş, İstanbul*.

Womack, J. & Jones, D. (2006), *Lean Thinking*, Simon & Schuster, New York, NY.

Womack, J. P., & Jones, D. T. (1997). Lean thinking—banish waste and create wealth in your corporation. *Journal of the Operational Research Society*, *48*(11), 1148-1148.

Womack, J. P., Jones, D. T., & Roos, D. (1990). The Machine that Changed the World: The Story of Lean Production HarperCollins Publishers. *New York, USA*.

Womack, J., & Jones, D. T. (1996). *Lean thinking: Banish waste and create wealth in your corporation.* New York: Simon and Schuster.

Womack, J., Jones, D. T., & Roos, D. (1990). The machine that changed the world. *New York: Rawson Associates*.

Womack, J.P & Jones, D.T. (2016). Yalın Düşünce. (Çeviren: O. Yamak), İstanbul: Optimist Yayınları.

Womack, J.P. & Jones, D.T. (2003). *Lean Thinking-Banish Waste and Create Wealth in Your Corporation*, 2nd ed., Simon and Schuster, London.

Womack, J.P., Jones, D.T., & Roos, D. (1991). The Machine that Changed the World: The Story of Lean Production. Harper Perennial, *New York.*

Wong, Y. C., & Wong, K. Y. (2011). Approaches and practices of lean manufacturing: The case of electrical and electronics companies. *African Journal of Business Management*, *5*(6), 2164-2174.

Wu, Y. C. (2003). Lean manufacturing: a perspective of lean suppliers. *International Journal of Operations & Production Management*, *23*(11), 1349-76.

Yafei, L., Qingming, W., & Peng, G. (2018, March). Research on simulation and optimization of warehouse logistics based on flexsim-take C company as an example. In *2018 7th International Conference on Industrial Technology and Management (ICITM)* (pp. 288-293). IEEE.

Yang, M. G. M., Hong, P., & Modi, S. B. (2011). Impact of lean manufacturing and environmental management on business performance: An empirical study of manufacturing firms. *International Journal of Production Economics*, *129*(2), 251-261.

Yasin, M. M., & Wafa, M. A. (1996). An empirical examination of factors influencing JIT success. *International Journal of Operations & production management*, *16*(1), 19-26.

Yasuhiro, M. (2004). Toyota Management System, Talbot Bruce.

Zavadskas, E. K. & Turskis Z. (2010). “A New Additive Ratio Assessment (ARAS) Method in Multicriteria Decision-Making”. *Technological and Economic Development of Economy, 16*(2), 159 172.

Zerenler, M., & Karaboğa, K. (2014). Müşteri memnuniyetinin sağlanmasında hataların önlenmesine yönelik üretim odaklı bir bakış açısı: Poka-Yoke sistemleri. *Selçuk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 263-275.

Zeybek, F. (2013). *Konfeksiyonda yalın üretim sisteminin etkinliği üzerine bir araştırma* (Doctoral dissertation, Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü).

Zimmer, E. R. (2006). *Improving Lean Supply Chain Management in the Construction Industry* (Doctoral dissertation, University of Cincinnati).

APPENDIX 1 – Criteria Developed for The Relationships of Wastes with Each Other

Note: Waste *i* refers to waste *j* which has an effect on other types of waste. For example, for O_I; *i:* Overproduction and *j:* Inventory or for O_D; *i:*Inventory and *j:* Defect.

Questions	Weight
1- Does waste of *i* manufacture waste of *j* ? a) Always b) Sometimes c) Seldom	 For a, 4 For b, 2 For c, 0
2- What kind of relation is there between *i* and *j* ? a) While *i* rise, *j* rise b) While *i* decrease, *j* decrease c) While *i* rise, *j* achieve a fixed level	 For a, 2 For b, 1 For c, 0
3- How is the impact of *j* because of *i* ? a) Its direct and clear effect is visible. b) It needs time for the effect to visible. c) Does not visible often.	 For a, 4 For b, 2 For c, 0

4- The elimination of *i*'s impact on *j* is reached by provides as follows. a) Lean tools b) Direct and easy solutions c) Education	 For a, 2 For b, 1 For c, 0
5- The impact of *j* from *i* essentially has the following effects: a) Product quality b) Productivity c) Delivery time d) Cost e) Effort f) Quality and efficiency g) Efficiency and delivery time h) Quality and delivery time ı) Quality, productivity and delivery time	 For a, 1 For b, 1 For c, 1 For d, 1 For e, 2 For f, 2 For g, 2 For h, 2 For ı, 4
6- To which degree does the impact of *i* on *j* raise production lead time? a) High degree b) Moderate degree c) Low degree	 For a, 4 For b, 2 For c, 0

APPENDIX 2 – QUESTIONNAIRE

1. What is your gender ?

a) Female ( ) b) Male ( )

2. What age range are you?

a) 20-29 ( ) b) 30-39 ( ) c) 40-49 ( ) d) 50-59 ( ) e) Over 60 years old ( )

3. What is the highest school you have completed or the highest diploma you have received?

a) Associate Degree ( ) b) Undergraduate ( ) c) Master's ( ) d) Doctorate ( )

4. How long have you been working in the firm?

a) Less than 5 years ( ) b) 5-10 years ( ) c) 11-15 years ( ) d) 16-20 years ( ) e) 20 years over ( )

5. How long has the firm been operating?

a) Less than 5 years ( ) b) 5-10 years ( ) c) 11-15 years ( ) d) 16-20 years ( ) e) 20 years over ( )

6. What is the total number of employees in your firm?

a) 30 and less ( ) b) 31-70 ( ) c) 71-100 ( ) d) 101-300 ( ) e) 301-500 ( ) f) 501-700 ( ) g) 701-1000 ( ) h) More than 1000 ( )

7. What is the name of the department you work for?

a) Production Manager ( ) b) Production Planning ( ) c) Production Engineer ( ) d) Production Supervisor ( ) e) Marketing ( ) f) Supply chain ( ) g) Lean Systems ( )

8. Do employees in your firm know, adopt and apply lean production practices?

a) Yes ( ) b) No ( ) c) Partially ( )

9. Which of the following lean production tools are used in your firm?

Andon ( )

Automation ( )
Cellular Production ( )
Heijunka ( )
Hoshin Kanri ( )
Jidoka ( )
Just In Time ( )
Kaizen ( )
Kamishibai ( )
Kanban ( )
Lean Six Sigma ( )
Poka-Yoke ( )
Single Minute Exchange of Dies ( )
Total Productive Maintenance ( )
Value Stream Mapping ( )
Visual Management System ( )
5S ( )