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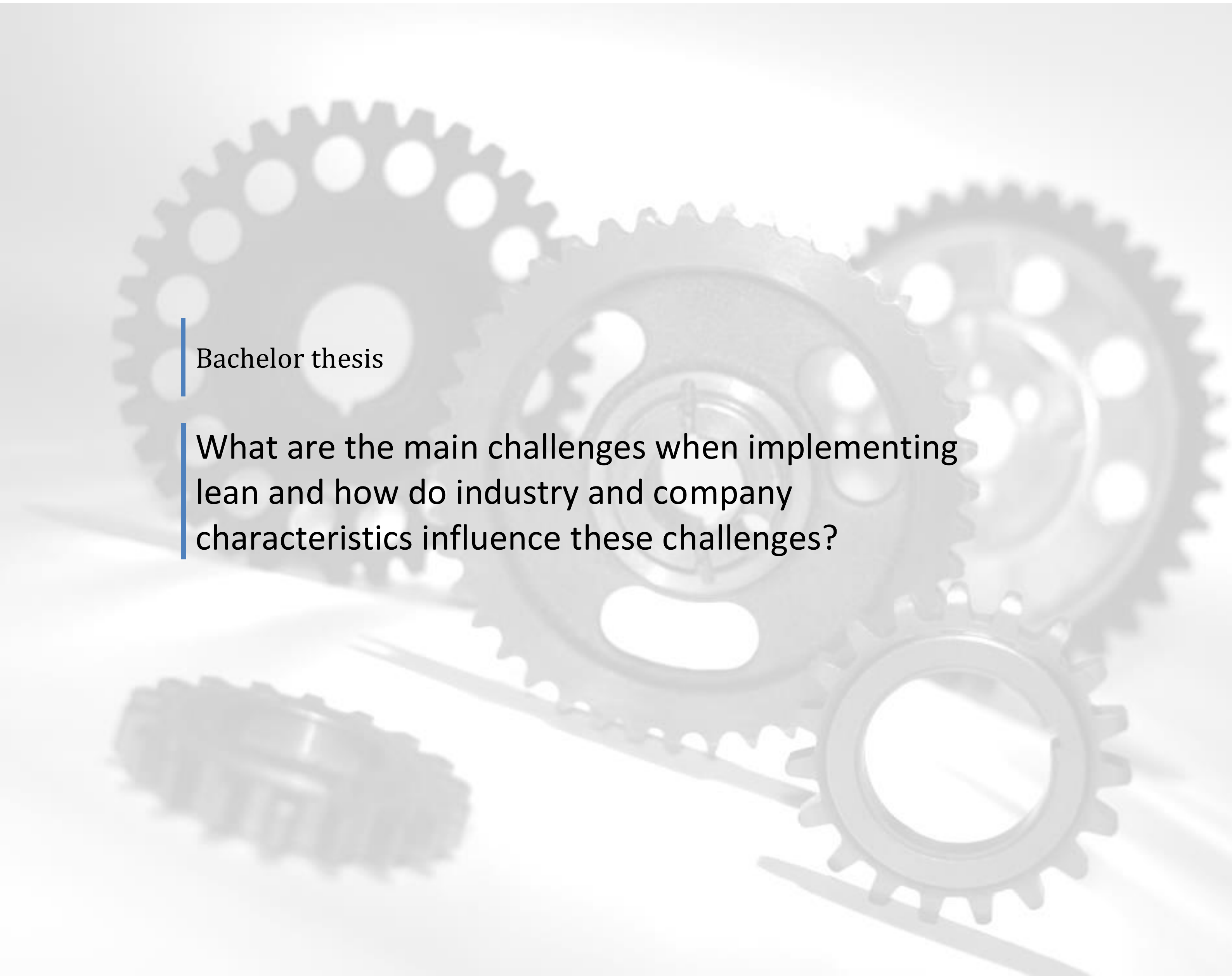

Bachelor thesis

What are the main challenges when implementing lean and how do industry and company characteristics influence these challenges?

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Introduction

The research question of this thesis '*What are the main challenges when implementing lean and how do industry and company characteristics influence these challenges*' will investigate the problems that arise when trying to implement lean in different production or service environments. The subject of lean implementation challenges has, until now mostly focused on specific industries and company characteristics. This paper tries to identify the challenges that are general and thus applicable to almost every lean environment. Besides the general challenges, this paper has the goal of identifying challenges that are specific to certain industries and company characteristics. By doing so, the author hopes to bring more clarity to the subject of lean implementation challenges which will be beneficial for people studying lean, as well as for lean practitioners and the body of academic knowledge.

Chapter 1 consists of a view into the history of lean and how it evolved. This will subsequently be followed by an analysis of what lean exactly is and what elements lean consists of. Chapter 2 will investigate the different general challenges of lean initiatives and give specific information about industry and company specific challenges. This chapter is followed by the conclusion and discussion.

1. What is the definition of lean and what are its main elements

1.1 The history and evolvement of lean thinking

One root of lean comes from the person of Sakichi Toyoda inventing a loom in 1924, that automatically stopped when a threat broke (Hayes, 2010). This was a groundbreaking method which saved a lot of time and guaranteed a high quality standard. The Platt Brothers bought the patent rights of the machines in 1929. The money that Sakichi Toyoda raised with the selling of the patent right was the seed-money for the Toyota Motor Corporation. A second root of lean can be found in the development of the first moving assembly line to manufacture cars, which was invented by Henry Ford in 1913 (Black, 2007). This production line can be seen as the first use of 'flow' in a production environment (Hayes, 2010). A third originator of lean thinking was the invention of continuous improvement, which can be traced back to the ideas of W. Edwards Demming. Demming brought his Plan Do Check Act (PDCA) methodology to Japan after World War II (Liker and Morgan, 2006; Hayes, 2010). Taiichi Ohno put those flow, quality prevention and continuous improvement ideas together to form the basis of the Toyota Production System also called TPS (Arlbjørn and Freytag 2013). After that, other elements are added which make lean how it currently is. All these elements will be discussed in the next paragraph.

It took a few decades before the philosophy and tools of TPS would reach the American and European business literature. This was mainly caused by the language and cultural barriers but also by the lack of interest of Western manufacturers (Hines et al., 2004). The book '*The machine that changed the world'* written by Womack and Jones in 1990 was the first to mention the word 'Lean production' (Black, 2007). This book, together with the success of Toyota at the American and European continent speeded up the process of integration of lean ideas in the western production environment. Since then, many non-Japanese firms have tried to replicate the success of Toyota, applying Lean thinking to their processes, but with highly varying results. Many of the companies that fail at applying Lean do not fully understand the fundamental elements of lean as developed by Taiichi Ohno. The understanding of lean is made more complex by the fact that lean is still constantly evolving (Pettersen, 2009). Schonberger (2005) already comes up with a new form of lean, formulated as '*lean extended'*. The next paragraph will try to give an overview and explanation of what the essential elements of lean are.

1.2 Defining main elements of lean and its concepts

Definitions of lean

Authors agree on the fact that there is no real clear definition of lean (Pettersen, 2009; Arlbjørn and Freytag 2013). Definitions given by Arlbjørn and Freytag (2013) are; '*doing more with less'* and '*manufacturing without waste'*. A central point of lean that is mentioned by his founder – Toyota executive Taiichi Ohno – is the elimination of waste or '*muda'* as the Japanese call it (Womack and Jones, 2003). A citation about the definition of waste found in Taj and Berro (2006), as cited in Arlbjørn and Freytag (2013; page 183) is '*waste is anything other than the minimum amount of equipment, materials, parts and working time that are absolutely essential to production'*. Chauhan and Singh (2012) define waste as '*any activity that absorbs resources but creates no value*'. Those activities can be in production but also customer relations, product design, supplier networks and factory management (Chauhan and Singh, 2012). Taiichi Ohno defined the seven wastes (Chauhan and Singh, 2012; Womack and Jones, 2003; Hayes, 2010) being;

1) overproduction;
2) excess motion (of operator, material or machine);
3) waiting (of operator, material or machine);
4) transportation;
5) excess processing;
6) inventory; and
7) defects (rework and scrap)

Other authors also added waste categories to this list, with '*goods and services which do not meet the needs of the customer*' (Womack and Jones, 2003; page 15). Waste is also '*unused employee creativity*' according to Czabke et al. (2008; page 78). Atkinson (2010) confirms this idea by giving the example that the average Toyota employee comes up with 187 ideas each year, of these ideas 98% gets implemented to improve the processes. Taiichi Ohno distinguished two types of waste being type 1 and type 2. Type 1 waste is waste that is not possible to eliminate with the current state of technologies and type 2 waste is waste that can be eliminated immediately.

Major components of lean

Pettersen (2009) did a literature study about lean techniques and/or goals. Pettersen searched for the keywords '*Lean production*' and '*lean manufacturing*' in the databases ISI and Scopus. Of those two databases the twenty most cited articles were selected. After screening the 37 unique articles found, 12 articles were selected, based on the criteria of containing presentations of techniques and/or overall goals associated with lean production. On the basis of citation rankings there were also 13 books included in the study. Pettersen (2009) grouped the lean characteristics he found in his literature study into nine collective terms as can be seen in figure 1, at the right of this page. Although this is not an exhaustive list of all tools and techniques available, it covers the

Collective term	Specific characteristics
Just in time practices (100%)	Production leveling (*heijunka*) Pull system (*kanban*) Takted production Process synchronization
Resource reduction (100%)	Small lot production Waste elimination Setup time reduction Lead time reduction Inventory reduction
Human relations management (78%)	Team organization Cross training Employee involvement
Improvement strategies (100%)	Improvement circles Continuous improvement (*kaizen*) Root cause analysis (5 why)
Defects control (100%)	Autonomation (*jidoka*) Failure prevention (*poka yoke*) 100% inspection Line stop (*andon*)
Supply chain management (78%)	Value stream mapping/flowcharting Supplier involvement
Standardization (100%)	Housekeeping (5S) Standardized work Visual control and management
Scientific management (100%)	Policy deployment (*hoshin kanri*) Time/work studies Multi manning Work force reduction Layout adjustments Cellular manufacturing
Bundled techniques (56%, 67%)	Statistical quality control (SQC) TPM/preventive maintenance

Note: The figures in parentheses indicate the percentage of the authors that have discussed at least one of the characteristics in the group

Figure 1; Grouping of lean characteristics as suggested by Pettersen (2009)

elements that are most central to lean. The seven wastes as described in the previous paragraph can, just like the nine lean elements, be seen as central to the lean practice and philosophy. Because the nine major lean components and the seven wastes are both central to lean, this chapter will explain those parts of lean together. A third part of lean that has become ingrained into the lean literature comprises of the five steps to lean as developed by Womack and Jones (2003). These steps are in chronological order: identify the value, identify the value stream, introduction of flow, getting customers to pull, and finally striving for perfection. These five steps can be seen as essential lean steps to a successful lean implementation and will therefore be combined with the explanation of the seven wastes and the nine lean elements. By connecting those steps to the nine major lean elements (Pettersen, 2009) it gets clearer in which stadium of lean implementation each lean term applies and which waste it reduces. At the end of this chapter there is the summarizing table 1, which simplifies and clarifies the connection between the nine lean terms, the seven wastes and the five steps to leanness.

Just-in-time practices

This component, consisting of production leveling, pull, takt production (standard time) and process synchronization can be abbreviated as JIT. The following will explain why JIT can be seen as one of the most important lean practices (Chauhan and Singh, 2012). The use of the Daily Demand is called 'leveling' or 'smoothing' of production (Black, 2007), Japanese use the word *Heijunka* (Liker and Morgan, 2006). The daily demand can be calculated with the following formula from Black (2007):

$$\text{Daily Demand} = \frac{\textit{Number of outputs per month}}{\textit{Number of days in month}}$$

Through the use of production leveling there are no sudden big fluctuations in the needed production capacity. Pull production means that there is only something produced when the consumer asks for it so overproduction (waste # 1) is reduced to zero. One of the tools that make pull possible is '*kanban'* also known as signal cards which give a signal to the preceding production step to produce. The kanban can be combined with visual controls like (empty) containers (Deflorin and Scherrer-Rathje, 2012). This way the end consumer can '*pull'* the product through the production process because the preceding steps get the signal to produce another product. Black (2007) formulated a calculation of how much containers are needed for the kanban function to work: $K = \frac{\text{lead time x daily demand + safety stock}}{\text{the number of parts in each container}}$

In figure 2 (Black, 2007) at the right, visualization of the working of this pull system can be seen. The manufacturing cell uses raw materials from the carts and returns the empty cars, which is a signal for the ordering of new raw material from suppliers. The full carts of parts are going to the subassembly where they are sub assembled. The returning of empty carts from sub assembly to the manufacturing cell is a sign to produce more parts, and so on, all through the production stages. It is important that there is no unnecessary waiting (waste # 3) for a previous or subsequent production step to be finished. Therefore it is essential that every step in the production cycle is adjusted to a standard time frame. This principle is also called '*takt time'* and it is the German word for 'conductor's baton' which is

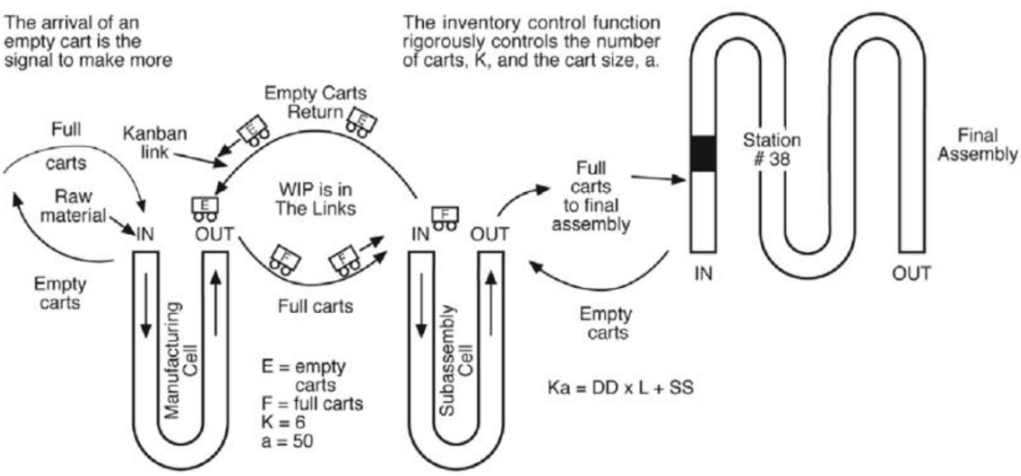

Figure 2; Example of the working of kanban system (Black, 2007) used to keep e.g. all orchestra members in time. Takt time is according to Chauhan and Singh (2012) one of the most used lean tools and can be calculated with the following formula from Black (2007):

$$\text{Takt Time} = \frac{\text{Minutes available per day}}{\text{Daily Demand}}$$

Black (2007) mentions that cycle time needs to be slightly less than takt time to work effectively. This makes sense because a cycle time that is shorter than the takt provides a buffer for machine change-over and/or problem solving. Process synchronization can also be called ‘flow’. When kanban is combined with the takt time there is the possibility of ‘one-piece flow’ which makes sure a product is worked on from the beginning to the end without interruption. This flow ensures that the product is finished as fast as possible (see waste # 3) which adds value to the end consumer and makes sure the work-in-progress is minimized. From the five steps from Womack and Jones (2003) the third (flow) and the fourth (pull) are present. JIT also minimizes waste number one (overproduction) and number three (waiting).

Resource reduction

Small lot production, waste elimination, setup-, lead time-, and inventory reduction are the parts of this lean component. Small lot production means that the batches are as small as possible, one is the most ideal (because this minimizes waste # 1 and # 6). Taiichi Ohno did use water as the analogy for inventories. In that analogy the water stands for the inventories in the production process. When the water level is high, the rocks on the bottom of the river (which symbolize the unexposed waste) are invisible. When the water (read inventory) level lowers, the rocks (problems) in the river become visible and can be removed, causing the river to flow even more faster and easily (Deflorin and Scherrer-Rathje, 2012; Liker and Morgan, 2006). So, by lowering the inventories, the waste of inventories (waste # 6) is minimized. Setup time reduction is also called Single Minute Exchange of Dies or SMED. The goal of this tool is to minimize the time that is needed to adjust a machine to the production of a specific product (waste # 3). Lead time reduction is partly achieved by the element of flow which minimizes the waiting between processes. Another way to shorten the lead time is by breaking production steps into smaller subsequent steps that are slightly lower than the takt-time. To make all the elements flow more easily and avoid unnecessary movement, the concept of u-shaped production cells has found to be the most efficient production method. The u-shape of these production cells minimizes the distance between machines while still using the production line principle where the product can flow from one machine to the other. The bonus of the u-shape is that it makes it possible for one employee to work on several machines in one ‘cycle time’. Those cells are typically manned by operators that are multifunctional and have been trained to perform many tasks and operate different processes (Black, 2007). See figure 3 for a schematic example of u-shape principle. When waste is eliminated only value remains, therefore resource reduction can be traced back to step one of Womack and Jones’s (2003) five steps. This first step is identifying the value. Because resource reduction enables the flow of the production process, also the third step is applicable here. Resource reduction reduces the first waste (overproduction) and the sixth waste (inventory).

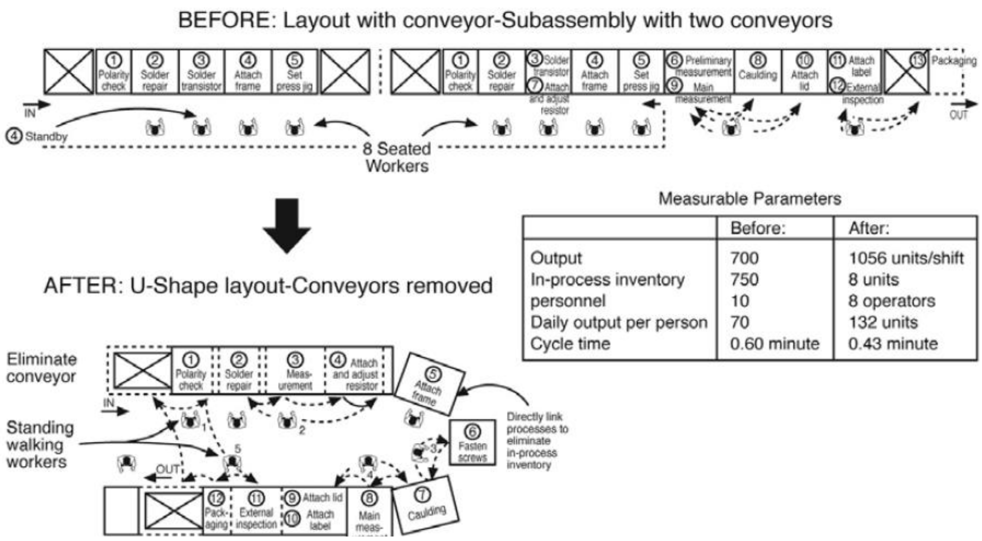

Figure 3; example of u-shaped production cell (Sekine, 1990)

Human relationship management

The three characteristics of this collective term are, team organization, cross training and employee involvement. Team organisation means that the workforce is organized in small teams, who are most of the time heterogeneous in expertise and are responsible for a part of the production process. This team can be responsible for a certain product or '*product family*'. Because the team members have different expertise and backgrounds they can approach the waste from different angles. The element of cross training means that employees are trained to do a variety of tasks. Task can include handling different machinery, doing quality checks (see waste # 7), or minor machine repairs (Deflorin and Scherrer-Rathje, 2012). This way, personnel can more easily replace people that are absent or help where extra capacity is needed so waiting time (waste # 3) is minimized. A cross trained workforce does not only make the company more flexible and responsive but also makes the jobs of the people themselves more interesting. Employee involvement is one of the essential elements of a lean implementation effort. When employees feel involved they are more susceptible to changing their behavior. Therefore all employees usually are involved in the decision making around lean in the company. Communication of the lean results involves the people and keeps them motivated. Waste number three (waiting) is lowered by being able to use employees where they are most needed at the moment. The seventh waste (defects) gets prevented by employees being trained to do quality checks. Because the workforce is cross-trained the third step of flow gets cultivated. Employees are trained to locate and eliminate waste, this element belongs in step five of Womack and Jones (2003), being striving for perfection.

Improvement strategies

Improvement strategies consists of improvement circles, continuous improvement, and root cause analysis. Improvement circles are teams that are multidisciplinary and therefore have a broader view of all the processes and can therefore locate waste in a broader scope. Continuous improvement can be traced back to the plan-do-check-act methodology of W. Edwards Demming, which now has the name Total Quality Management or TQM in short (Womack and Jones, 2003). The term TQM is an accumulation of failure prevention and quality checking tools. *Kaizen* events can also be seen as continuous improvement processes. In a Kaizen event certain specific improvement goals are tried to be made with the use of teams that are focusing on a certain element of waste (Farris et al., 2009). Root cause analysis is also known as the 5 why's because this is the lean tool that is used to get to the root of a cause by asking why five times. The idea behind this theory is that when there is a problem, you need to ask 'why' five times to come to the root cause of the problem. Step five of lean – striving for perfection – applies here. The improvement strategies are used to eliminate all the seven types of waste.

Defects control

The four elements are, autonomation, failure prevention (poka yoke), 100% inspection, and line stop (andon). To make sure there are no defective products produced, there are visual and sometimes electronic controls embedded in every process step. This autonomation concept is called *Jidoka* (Womack and Jones, 2003). This way a defect can be detected immediately instead of at the end when the product is finished. Whenever personnel (or a machine) sees a defect or when something else is going wrong the line stop '*andon'* cord or button is used to stop the machine, or it can automatically stop itself (Liker and Morgan, 2006). Then a quality manager will speed to the location of the problem that is located by a light or a sound (Liker and Morgan, 2006). A promise from the management of NUMMI cited by Shook (2010; page 66) is '*Whenever you have a problem completing your standardized work, your team leader will come to your aid within your job cycle*'. Failure prevention is also called poka yoke in Japanese. Where Jidoka is more about finding problems, poka yoke is there to prevent them from happening. An example can be that a conveyer belt can only move when a laser beam has been interrupted. This way the machine for example knows that the worker picked the necessary part out of the box. 100% inspection just means that all the products are checked in all the subsequent production steps. The seventh waste of defects is minimized by the defect controls. Because defective products do not get processed further, the fifth waste of excess processing is minimized as well. With lean production zero defects are the goal, the fifth step of striving for perfection is therefore most applicable here.

Supply chain management

Value stream mapping and supplier involvement are part of supply chain management. Value stream mapping can be abbreviated as VSM. VSM is actually the component that needs to be used before the other lean elements can be implemented. By mapping the value stream of a product (or service) it gets clear where there is waste that can be eliminated. Chauhan and Singh (2012) state, that VSM is one of the most used lean techniques. This is probably because this tool is very helpful in finding the waste that is central to the lean philosophy. For lean and especially Just-in-time to work it is essential that suppliers are involved in the process of lean (Lyons et al. 2013). Waste can be along the whole value stream from raw material to end product. When your own company is lean but your suppliers are not, there will still be waste in the supply chain of the product. Therefore it is optimal to create lean processes over the whole product supply chain. The second step in lean implementation – identifying the value stream – is applicable in supply chain management. The fourth step of pull is made possible by involving suppliers in the lean methodology. With this lean concept the sixth waste of inventory is minimized.

Standardization

Besides standardized work, standardization also consists of housekeeping and visual control as identified by Pettersen (2009). Housekeeping can also be called 5S'ing. Chauhan and Singh (2012) mention 5S as one of the most used lean techniques. 5S stands for sort, straighten, shine, standardize, sustain. When those five words are applied in the workplace, the tools and equipment are easy to locate, clean, and ready to use. Standardized work means that all the production steps are standard. This way a worker can easily work in different production cells. Another benefit is that when certain improvements are found, they can immediately be applied to all the other production areas. A visual control has overlap with Jidoka and kanban who have been discussed earlier. Standardization fights waste number two (excess motion) because no one has to look for where tools are because they have a fixed location. Standardization can be assigned to step three (flow) and step five (perfection) because less excess motion inhibits flow and the applicability of improvement ideas to the whole chain is supporting the goal of perfection.

Scientific management

Policy deployment, time/work studies, multi manning, work force reduction, lay out adjustments, and cellular manufacturing are the elements of scientific management. Policy deployment is also called *Hoshin Kanri* and includes delegating as much responsibility as possible to the workforce. In short, it is a management system in which all employees participate. Time and motion studies overlap with lay out adjustments because they both want to optimize the output of activities. By changing the lay out of the machinery, the needed time and motion can be reduced. Cellular manufacturing means that machines and equipment are placed together to reduce walking time and distance. Most production cells have a U-shape and are manned by operators who are multifunctional and can perform many tasks and operate many processes (Black, 2007). Decouplers are used to connect different machines. Those decouplers can perform quality checks and the function of process delay. The capacity of a decoupler never exceeds two unless it is performing a function of process delay (Black, 2007). A manufacturing cells is built in such a way that it can be operated by one person, so multi manning is in place. Scientific management minimizes the excess motion (waste # 2) and transportation (waste # 4) between different machines. The lay out adjustments make a product move easier and faster so therefore the third step of flow is most applicable to this lean component.

Bundled techniques

Statistical quality control is used to calculate the impact of certain changes in the system on the number of total defects. This process is also known as '6 sigma', but is not an essential application for the adoption of lean thinking. Maybe this explains the fact that this element has only a 56 percent out of the total literature. Total productive maintenance or TPM in short, is more popular among lean adopters than 6 sigma. The goal of TPM is to make sure that there are no machine failures because this causes the waste of waiting personnel and it inhibits the flow of the products. Therefore parts are replaced before they are broken to make sure the machines will always be able to function. 5'sing can also be seen as a great addition to TPM because for example oil leakage is much faster identified when the machine is clean ('shines') instead of when it is covered in dirt and oil. Statistical quality can measure and thereby reduce the waste of defects (waste # 7) and TPM prevents machine down time, so also prevents unnecessary waiting (waste # 3). 6 sigma can be placed under the umbrella of step 5 – striving for perfection - , while TPM ensures the flow of products, therefore being part of step 3 – creating flow.

Major lean component overview

This chapter did describe the nine lean elements as developed by Pettersen (2009) that together form the tools, techniques and strategies to a complete lean implementation. The core of lean revolves around minimizing all of the seven wastes as described in chapter 1, page 3 of this thesis. The seven wastes where developed by Taiichi Ohno (Chauhan and Singh, 2012; Womack and Jones, 2003 and Hayes, 2010). Womack and Jones (2003) identified their five steps (as described on page 4 of this thesis) to lean which are all crucial to enabling and maximizing the lean implementation. The seven wastes, together with the five steps to lean are irrefutably connected to the working and understanding of the elements of lean. Each lean element reduces one or more of the seven wastes and fits in at least one of the five steps to lean. Table 1 tries to connect the nine elements of lean to the context of those seven wastes and five steps to lean. By knowing which step fits each lean element, the right sequence of implementation can be achieved. Seeing which tools, techniques and strategies are contributing to the reduction of a certain waste can be useful in choosing which lean element can best be deployed for achieving a certain goal.

The lean elements	reduce the lean wastes							and fits the following lean steps (as mentioned by Womack & Jones (2003)
	over-production	excess motion	waiting	transport	excess processing	inventory	defects	
Just in time	x		x					creating flow / establishing pull
Resource reduction	x					x		indentifying value / creating flow
Human Resource management			x				x	creating flow / striving for perfection
Improvement strategies	x	x	x	x	x	x	x	striving for perfection
Defects control					x		x	striving for perfection
Supply Chain Management	x		x			x		identifying the value stream / establishing pull
Standardization		x					x	creating flow / striving for perfection
Scientific Management		x		x				creating flow
Bundled techniques			x				x	creating flow / striving for perfection

Table 1; The nine major lean elements in relation to the seven wastes and five steps to lean

Lean outside of car manufacturing

Lean originates from the high volume, low variety (mass) car manufacturing of Toyota but is since its discovery outside Japan, also applied to many other disciplines. Service industries (Suárez-Barraza et al., 2012) like healthcare (Mazzocato et al., 2010), hotels (Vlachos and Bogdanovic, 2013) and restaurants, governments (Scorscone, 2008), financial institutions (de Koning and Does, 2008) and education have adopted elements of lean. Also within production itself, lean has extended to the processing industry (Dora et al., 2013; Lyons et al., 2013), and the craftwork industry (Deflorin and Scherrer-Rathje, 2012). All these different environments have specific challenges when implementing lean but there are also lean challenges that are general. The next chapter will discuss the lean challenges as identified in the literature in three groups of challenges.

2. Lean implementation challenges

This chapter will describe the challenges that are faced when trying to implement lean thinking. The challenges are mainly formulated from the perspective of the lean stereotype by Wilson (2010). These stereotype elements consist of being a manufacturing firm, producing discrete parts and having stable product demand. Many challenges are also applicable outside the roam of this lean stereotype. Eroglu and Hofer (2011) found in their research that some industries, because of the particular product, or the conditions of manufacturing, demand, or supply may not be suitable to lean operations. Shah and Ward (2003) on the other hand state that lean practices are prevalent in all industries. This chapter will try to bring nuance to these two opposing statements.

The nine elements from chapter 1 can be divided into three broad groups, being resource related, people related and variability related. On the basis of the implementation challenges found in the literature study, a matrix of the nine lean elements and the found lean challenges has been made. This matrix (see annex 1) allowed for the identification of lean components that more or less share the same challenges. The lean components arising from the matrix were identical to the classification that could be made on the basis of the underlying goals. This finding did cause the classification of challenges into three groups. These three groups are 'resources management', 'people management' and 'standardization'.

The 'resources management' group consists of JIT, resource reduction and supply chain management because these lean components have the reduction of the needed resources as a central goal. The second group named 'people management' is formed by HRM, improvement strategies and scientific management, because most of the challenges in these lean elements are caused by or at least involve people. Defects control, standardization and bundled techniques are forming the core of the 'standardization' group because these three groups all want to lower the variability by standardizing processes. For structuring the paragraphs of this chapter, these three lean element groupings are used to discuss the lean challenges found in the literature. Some challenges might have a slight overlap between two or three of the groupings. In that case the author has tried to fit the challenge under one of the three components that has the highest relevance.

2.1 Resource management

The first of the three lean components is resource management. This lean component consists of the three lean elements; just in time practices, resource reduction and supply chain management. Each challenge as identified in the literature will be explained and discussed. First the generally applicable challenges will be discussed, after that the industry specific and company specific challenges will be identified. The table below already summarizes the content of this paragraph for an overview of the challenges identified.

Overview resource management challenges		
General	**Industry specific**	**Company specific**
- Applying lean in a holistic way; - Taking the right steps in the right order; - Not exaggerating inventory leanness; - Preventing corporate anorexia; - Getting suppliers to cooperate	*Mass production* - Synchronize processes to takt time *Processing* - Reducing batch sizes; - Lowering set-up time; - Try to implement JIT; - Integrate suppliers;	- Small firms are less likely to have lean success; - Low competition and/or unstable demand inhibit succesfull lean implementation

Table 2; Overview of the identified resource management challenges

2.1.1 General resource management challenges

Having a holistic approach to lean

The first and probably one of the most important lean challenge discussed in this thesis is the implementation of as many lean tools and techniques as possible. Many researchers found that it is far better to try to combine many different lean tools, instead of '*cherry picking'* some tools and trying to apply them. This is because all the lean tools reinforce each other (Scherrer-Rathje et al, 2009; Dora et al., 2013; Angelis et al., 2011) because they are complementary (Chauhan and Singh, 2012). Many companies trying to apply lean only focus on the tools and neglect the necessary cultural changes (Losonci et al., 2011; Liker and Morgan, 2006; Hines et al., 2004). Only applying the tools without changing the company culture will almost never bring optimal results (Mann, 2009). So using many lean tools, combined with making the right cultural changes is a challenge every company with lean aspirations has to deal with.

Taking the right steps in the right order

As with everything in life, taking the right steps in the right order is crucial. When there is a tendency to skip essential steps in the process, problems will arise sooner or later. The first thing to do is to redesign and simplify processes before trying to reduce resources, because otherwise implementations often result in failure (Black, 2007; Bhasin, 2012c; Shah and Ward, 2003; Liker and Morgan, 2006). Chauhan and Singh (2012; page 59) describe this well by stating '*before results can be improved, the process must be improved*'. Bortolotti and Romano (2012) support this statement with their paper around the framework of '*lean first, then automate*' in which they plead for process improvement before starting to automate processes. For tackling this problem, the five steps to lean as developed by Womack and Jones (2003) can give the right directions in combination with the table that combines these steps with the lean elements. The house of lean as developed by Liker and Morgan (2006) can also be a helping hand in deciding which order of implementation to use.

Not exaggerating inventory leanness

Lean is about minimizing waste and resources, but exaggerating this philosophy can be harmful. Eroglu and Hofer (2011) for example found that there seems to be an optimal level of inventory leanness. This optimal level depends on multiple factors like the cost of carrying inventory, the costs of shortages and the technology of production. Firms that have inventory levels slightly below the industry average, in general perform the best in terms of returns on the stock market. 48% of the researched industries had an inverted U-shaped relationship between the inventory leanness and performance. This finding suggests that the benefits of lean inventory get exhausted at some point and turn into a negative effect. The negative effects of excessively low inventories are mainly caused by high costs of transportation and stock outs. The theory of lean does not say that all inventories are bad, only the inventories that are unnecessary. The point about to low inventories is supported by Black (2007; page 3661) mentioning; '*While zero defects are a proper objective, zero inventory is not possible*'. The minimum level of inventory depends on many factors, Black (2007) mentions quality, probability of machine brake down, length of setups, variability, number of workers in a cell and transportation distance. Black (2007) gives the following rule; maximum inventory = daily demand x lead time + safety stock. Angelis et al. (2011; page 576) mention research stating that '*unbuffered lines with task coefficients of variation (CV) from 0.1 to 0.5 can reduce potential output by 10-35 percent, while modest buffers of ten times the CV recover 80-85 percent of capacity lost due to variability'*. Angelis et al. (2011) also mention that buffers reduce the pressure felt by workers. In the beginning of lowering the inventories, the current inventories can serve as a good buffer to make sure the whole process is not suffering from the waste that is exposed while lowering the inventories (Liker and Morgan, 2006). Eroglu and Hofer (2011) found that one third of the industries in their research seem to have no significant benefit on firm performance from applying inventory leanness. Examples of those industries are petroleum refineries, paperboard mills, iron and steel mills and storage battery manufacturers. Because these companies can be seen as firms in the continuous process industry there is confirmation that the stereotype of Wilson (2010) is right about the higher possibility of misfit of lean in the continuous process industry. Therefore firms in this industry need to be cautious and not

blindly adopt the lowering of inventories if they want to generate optimal results.
Not only lowering the inventories to much can be harmful. Angelis et al. (2011; page 580) state '*increased work pace has potential for causing excessive leanness*'. The results of their regression analysis show that emphasizing on speed over quality; together with a high level of work pace and intensity have a negative influence on workers affective commitment. Angelis et al. (2011) therefore advise to use buffers because this reduces the pressure and stress that is felt, while increased cycle times make it possible to speed up for a portion of the time and then rest for the remainder. When buffers are used between workstations, together with longer cycle time and job rotation the employees will feel less stress and be more motivated to do their job. When lean gets exaggerated, lean can become corporate anorexia. Radnor and Boaden (2004; page 431) state the following '*by striving to become lean by focusing on the process rather than the outcome, they miss the optimum point and move into anorexia, becoming relatively ineffective overall*'.
Radnor and Boaden (2004) created five questions that need to be asked about a company. When at least one of them can be answered with yes, there might be a case of corporate anorexia. The more yes'es , the more severe the problem is according to this theory. In the four cases at the right hand side of this page, the case 1 and 4 are considered lean, while case 2 and 3 are potentially anorexic.

	Case 1 Nortel	Case 2 UKChem	Case 3 Northern Shampoos	Case 4 Waferfab
No realisation of the stage of journey		✓	✓	
Moving beyond "fitness for purpose"		✓		
Some imbalance of facets	✓	✓	✓	✓
Some facets being stretched		✓	✓	
Potential difficulty in changing markets		✓	✓	✓
Total number of ticks	1	5	4	2

Figure 4; Corporate anorexia indicators (Radnor and Boaden, 2004)

Getting suppliers to cooperate
For lean and especially Just-in-time to work in the whole product value chain, supplier involvement is crucial in the process of a lean implementation (Lyons et al. 2013). For a supplier to commit to becoming lean, it is important that there is mutual trust that the relationship will be lasting and beneficial. For that reason there has to be good communication between both parties right from the start of the lean initiative.

2.1.2 Industry specific resource management challenges
Besides the general implementation challenges of resource management there are also some, challenges that are more specific to certain industries or companies. This paragraph will handle the industry specific challenges and 2.1.3 will deal with the company specific challenges.

Industry specific resource management challenges
For the sake of simplicity this paper distinguishes only four types of industries. These four types are, mass production, processing, craft production and services. The literature study only identified industry specific resource management challenges in the mass production, processing and service industry.

Mass production
A mass production environment already has standardized processes in place. Therefore the most important thing to do in a mass environment is to synchronize the processes to a takt time. (Deflorin and Scherrer-Rathje, 2012). Of course it stays important to check if there is waste in the already standardized processes, because otherwise the production capacity will suffer because of the waste that is standardized into the processes.

Processing
Before talking about processing it can be helpful to give a short explanation of what it means. A clear definition of processing is formulated in the paper of Lyons et al. (2013; page 480); '*Production that adds value by mixing, separating, forming and/or performing chemical reactions. It may be done in either batch or continuous mode*'. Lyons et al. (2013) describes the difference with manufacturing as the fact that process manufacturing produces measurable instead of countable produces.
Wilson (2010) states that the deviation from discrete parts to continuous process industry has the least

negative effect of the three elements of the lean stereotype he identified. In the continuous process industry the batch sizes are generally larger. The advice from Wilson (2010) to those firms is to reduce the batch size in order to make JIT function more properly. This brings us right to the next important lean barrier for processing industries. When the batch sizes are lowered, the setup time needs to be lowered to compensate for the need to change the set up of the machinery more often. According to Dora et al. (2013) The processing machinery is often large and therefore inflexible. Also the complexity of resources can be an influencing factor. Shah and Ward (2003) found that plants in discrete parts industries have a higher likelihood of implementing JIT (Just In Time) and that plants in process industries are more likely to implement TPM (Total Productive Maintenance). For companies in the processing industry there is much to be gained in comparison to the competition when implementing JIT practices. Lyons et al. (2013) state that supplier integration and the alignment of customer demand with production are 'structural' principles of lean, but are less apparent across different types of processing firms. Knowing this, a processing firm can get an advantage to their competition by implementing lean in a more holistic way.

Dora et al. (2013) concluded that lean in the food processing industry is not really developed yet. The focus is more on food safety than on process improvement methods. According to Dora et al. (2013) there are several reasons why lean manufacturing has a low impact to the food sector because of characteristics including shortness of shelf-life, raw material heterogeneity, seasonality, and varied harvesting conditions. Dora et al. (2013) also mention the complex production chains and networks of buyers and sellers as factors affecting food processing. Because of the heterogeneity, seasonality and varying harvest conditions it is hard, maybe even impossible to standardize these processes and use the methods of flow and pull.

Service
Service firms that want to apply lean have the problem of demand instability (Wilson, 2010). Radnor et al. (2012) and Edwards et al. (2012) also both mention this problem of instable demand. Although the problem gets recognized, none of the authors come up with a solution to this problem. Therefore the only thing that service companies can do is cross-train their workforce in order to being able to distribute people to the department within the company where extra capacity is needed.

For not for profits and charities, survival is not the most important issue. They sometimes find ways to spend money that they did not need to use because of subsidies and budgets. This creates waste, rather than eliminating it. The most important application of lean in these companies can be in the lower levels of the organisation where at the 'service provider level' lean tools can be used for the processes according to Wilson (2010). We think that standardization and more cross functional functions can help not for profits and charities to be more flexible and responsive.

2.1.3 Company characteristic resource management challenges

Company size
Company size is often mentioned (Shah and Ward, 2003; Eroglu and Hofer ,2011; Sim and Rogers, 2009) as a key characteristic of lean success. This statement gets backed up by the findings of Shah and Ward (2003) that plant size seems to be significantly positively correlated with twenty of the twenty-two lean manufacturing practices they examined. Only cross-functional work force and quality management programs are not statistically significant. It is important to mention that Shah and Ward (2003) found that the effect of size seems to be of less influence in the service industry than in the manufacturing industry. The higher influence of size on manufacturing than service is probably caused by the difference in the extent to which can be profited from economies of scale. Because services cannot easily be automated, the economies of scale principle is less relevant in the service sector. Dora et al. (2013; page 161) found research suggesting that '*large manufacturers are more likely to implement lean practices than small ones*'. This is in line with Eroglu and Hofer (2011) who say that small firms seem to benefit less from lean implementation than large firms. Many small and medium sized firms have limited power to dictate lean supply form their suppliers (Achanga et al., 2006). Because larger firms have more power, they are also

more likely to implement lean across the wider value chain and thus reap the full benefits of lean (Bhasin, 2012b). Evidence that larger firms are more likely to implement lean into the full value chain is found in the study of Bhasin (2012b) where was found that continuous improvement of the supply chain was an aspiration of 47% of small, 53% of medium and 74% of the large organisations in the study.

Market environment

The first essential element of a lean company is a competitive free-market environment, because otherwise there will not be enough motivation to undergo the sometimes enormous discomfort and cultural change. Not for profits and charities have, as mentioned earlier, no real competitive environment which results in lower motivation and less drive to implement the lean tools and philosophy.

Other companies that are in a free-market environment can also give lower priority to lean because there is no direct need for improvement. The research of Eroglu and Hofer (2011) found for example that companies that are in industries that have a higher gross margin, appear to have more positive results from inventory leanness. This seems a very plausible fact because the companies in these industries normally do less feel the need to increase efficiency because of the high margins. Therefore it is likely that in these industries there is a lot to be gained when implementing lean.

Demand stability

Wilson (2010) states that unstable customer demand makes the operational techniques of lean less applicable. Cooney (2002) makes the same statement by saying that production leveling is very difficult, if not totally impossible when volumes and product content are continually changing.

Cooney (2002) concludes that JIT-flow is not applicable for new businesses for which it is not possible to build long-term supplier contracts and thus have stability of demand. To keep lead times low, quick changeover techniques must be very strong in this type of business. Wilson (2010) states that reducing lead times pays in three ways. The first thing is that shorter lead times lead to less rework so higher quality. Second, the quicker deliveries improve the cash flow and the shorter lead times are also a weapon to acquire future business. Naturally the demand variability will be higher with luxury goods than with goods or services of which the demand is unattached with the economic situation or government policy.

Financial resources

The majority of small and medium sized firms are by the virtue of their size constrained by lacking adequate funding and a deficiency of leadership (Achanga et al., 2006). Bhasin (2012c; page 405) came to the same conclusion in stating that *'evidence exists to support that large plants are more likely to possess the resources to implement the lean practices compared to smaller organisations'*. This statement is underpinned with the findings of Bhasin that 75% of small organisations experiences cost of the investment as a barrier to lean. For medium and large organisations this number was significantly lower at 43% and 45%. Logically Bhasin (2012c) concludes that securing the additional funding for lean implementation is the most important for small organisations. When companies have little financial resources available to start with lean, they can try to look for the '*low hanging fruits'* although it is not being recommended for lean to function at its best (Dora et al., 2013). Womack and Jones (2003) state that firms can first try to lower their inventory a little and then try to pay the first lean initiatives from the cashflow of the lowered inventory. Black (2007) comes up with the following plan '*the use of existing machines is a low-cost, risk free approach because the existing processes have been proven and the components made by the processes tested in service*' Black (2007) calls this the '*interim cell* approach'.

Conclusion resource management challenges

At the end of this paragraph we can conclude that it is important to implement lean tools and techniques in a holistic way. While in the implementation process, it pays to carefully consider which steps to take, in order to prevent sub optimal results or even failure. Constantly keeping in mind not to exaggerate and overdo the lean initiative will increase the chances of a successful implementation. The last general challenge is to get suppliers to cooperate by winning their trust, showing them the benefits and involving them in the lean process.

Mass producers need to focus on the synchronization of the processes to takt time because standardized processes are already in place. Processing firms have more points of attention. They need to try to lower batch sizes, while at same time reducing their set-up time. By implementing JIT and trying to integrate suppliers, processing firms can stand out from their competition and create a competitive edge. Service firms need to cross-train their employees in order to being able to try to compensate for the instability of demand in the service sector.
The size of a company has strong influence on the likelihood of a successful lean implementation. Larger firms in general have more (financial) resources available and have more negotiating power towards suppliers. Therefore large companies can more easily and holistically implement lean. A lack of a market free environment or demand stability lowers the chances of success for firms with lean aspirations.

2.2 People management

The second of the three lean components is people management. This lean component consists of the three lean elements; human resource management, improvement strategies and scientific management. This paragraph is by far the one with the greatest number of challenges. The great number of challenges is probably caused by the fact that it is hard to change a culture and because people have their own will and personal agenda. Farris et al. (2009) state that the relationship between the degree of human resource implementation and lean manufacturing success has been reported in several studies. Losonci et al. (2011, p. 31) phrase the sentence: '*We know very little about the causes of implementation problems, but the evidence seems to suggest that human resource issues often are their root*'. Each challenge as identified in the literature will be explained and discussed. First the generally applicable challenges will be discussed, after that the industry specific and company specific challenges will be identified. Just like in the previous paragraph, the table below summarizes the content of this paragraph for an overview of the challenges identified in the literature.

Overview people management challenges		
General	**Industry specific**	**Company specific**
- Getting rid of the short term philosophy; - Establishing, maintaining and showing management commitment; - Establishing clarity, purpose and priorities; - Showing people how they are going to benefit; - Turn the blame culture into a positivity culture; - Avoiding employee resistance; - Creating employee commitment; - Train all employees for sufficient lean skills; - Give the workforce authority for continuous improvement; - Keeping track of the lean implementation results; - Fitting the compensation plan with lean; - Avoid sliding back to the old ways of doing things	*Mass production* - Getting people to do more than one task; - Getting people to solve problems *Craft production* - Get workforce to adapt knowledge to new standardized applications; - Getting people to communicate solutions; - Motivating workforce to the new environment *Services* - Cross-train the workforce for more flexibility; - Make lay-out adjustments in hospitals; - Try to holistically implement lean in healthcare; - Create standardized operating procedures; - Government is restricted by law and regulations	- Small firms have less employee resistance; - Small firms have trouble with training supervisors; - Small firms are more likely to lack know-how for lean implementation; - Owner managed firms have less ROI improvement; - Older and more skilled employees have more resistance towards lean initiatives; - Unionized firms are less likely to implement some lean tools and practices; - Union member workers have lower stress levels during lean implementations; - Older plants are less like to implement some lean tools and practices; - Gender influences the rewarding preference and stress levels during lean implementations; - High personell cost firms, profit more from lean; - Failed previous initiatives have influence on buy-in

Table 3; overview of the identified people management challenges in this paragraph

2.2.1 General people management challenges

Getting rid of the short term philosophy

To make a chance of real and lasting lean success, the company philosophy often needs to change. Company executives need to realize that there are no quick fixes to getting lean. This is emphasized by Scherrer-Rathje et al. (2009) who call implementing lean '*a daunting task*'. So, the idea of the existence of a lean template that is ready to use for implementation is incorrect. No two companies are exactly the same; therefore do not try to find a universal implementation manual and do not try to precisely copy the methods of others companies that already successfully implemented lean. Firms that want to become lean need to be aware of the fact that a lean transformation is not a one-time effort but a never ending pursuit

(Deflorin and Scherrer-Rathje, 2012; Scherrer-Rathje et al., 2009; Mann, 2009; Bhasin, 2012c). Because not all the lean results are financial, there is a need for looking at both financial and non-financial results (Black, 2007). Fullerton and Wempe (2009; page 229) confirm this by stating '*lean manufacturing practices are effective when accompanied by the complementary use of performance measures that provide informative and motivating information in world-class manufacturing environments*'. Like with almost all habitual changes, results will almost never be visual immediately, therefore management needs to get rid of the '*make the month mentality*' and be patient for the real lasting results to appear (Chauhan and Singh, 2012; Wilson, 2010; Bhasin, 2012c).
Womack and Jones (2003) state that it takes at least five years for a company to become truly lean. This statement is in line with the experience of Koenigsaecker (2000). Koenigsaecker classifies the first two years as '*disharmony and anti-change'*, the third year as stabilized change and 'b*uilding the long-term foundation*'. Beyond year three, the results start to add up and change becomes the norm and the workforce starts to have '*pride in lean accomplishments'*. Conti et al. (2006) did research on the effects of lean implementation on employee stress levels. They found that stress first starts to rise when the level of implementation gets higher, but that there is an inflexion point at which the stress levels starts to decline again. The morale of this information is to have an implementation horizon of at least five years, to give the stress and discomfort of change the opportunity to develop into a feeling of positivity and triumph.

Establishing, maintaining and showing management commitment

Maybe even the most important guideline every lean aspiring company should follow is to let senior management show their commitment and involvement to the lean initiative (Scherrer-Rathje et al., 2009; Dora et al., 2013; Angelis et al., 2011; Black, 2007; Chauhan and Singh, 2012; Boyer and Sovilla, 2003; Achanga et al., 2006; Sim and Rogers, 2009). Management can show their commitment through providing sufficient resources to the lean journey. This commitment can be in the form of time, money and active involvement. Bhasin (2012c) found that more than half of the 68 surveyed organisations feel that the added responsibilities of lean, cause a struggle with the time needed to implement lean. So, besides active involvement and money, senior management must also provide middle management and line-workers with the necessary workload relief to avoid a shortage of available time to spend on implementation issues. Being able to pay for the development of skill and expertise is found to be one of the most important success factors (Dora et al., 2013; Angelis et al., 2011; Shook, 2010). So, sufficient financial resources have to be made available to cover the cost of training, external consultants and other related costs.

The active involvement of management in lean activities must not be undervalued. Successful case studies like Losonci et al., (2011) mention CEO's or senior managers to walk around the shop floor and participate in improvement activities. Mann (2009) advises executives to spend one hour, every week or two, to spend on '*gemba walking*' (gemba means 'where the work is done'). According to Mann (2009) the first six months to a year of gemba walking can best be done together with a lean teacher or consultant.

Establishing clarity, purpose and priorities

Management must not only try to show their commitment to lean. According to Wilson (2010) and Achanga et al. (2006), lacking an implementation plan is an important reason for lean implementation failures. So, an important task of (senior) management, is to come up with a lean implementation plan with clarity and purpose (Wilson, 2010; Bhasin, 2012c; Hines et al., 2004). Also having a clear prioritization in the plan is important because it is better to work on a specified project than wanting to do it all at once (Bhasin, 2012a; Womack and Jones, 2003). The successful case study of Crute et al. (2003) emphasizes the importance of clear and specific goal setting. When goals are too vague, cannot be measured or are not able to be traced back to lean initiatives, the motivation among the workforce will decrease fast.

Showing people how they are going to benefit
Be clear from the beginning why your company is going to implement lean and also tell people how they are going to benefit from it (Bhasin, 2012c). When individuals recognize that change will be in their best interest they will help the implementation to move forward (Losonci et al., 2011), otherwise employees that have fear of infringements and job losses are prepared to cause sabotage which cause the process to slow down (Boyer and Sovilla, 2003; Achanga et al., 2006; Bhasin, 2012a). Research and case studies (Deflorin and Scherrer-Rathje, 2012; Crute et al., 2003; de Koning and Does, 2008) emphasize the importance of a pilot project within the company. A pilot means that one production cell is created, most of the time in the part of the production where there can be made an easy gain fast. Involve your personnel in the pilot project under the support of a lean consultant. When those workers experience the benefits of lean, they will be a living advertisement for the lean effort. This accompanied with the improved productivity figures will win the approval of most of the workforce. Labor forces generally do not want to be cross trained (Schonberger, 2005) so showing them the benefits of more variation in their work and extra skill development can be an effective method. Another good motivator can be to mention that employees get the chance to solve the inconveniences they are dealing with for several years (Deflorin and Scherrer-Rathje, 2012).

Turn the blame culture into a positivity culture
Companies often have a blame culture where managers always look which employee is to blame for a mistake or problem. This blame culture has a negative influence on lean implementation efforts (Angelis et al., 2011; Dora et al., 2013) because no employee will report failures or mistakes because of the fear to be blamed. When the culture changes from focusing on who is to blame to what the problem is that caused the defect in the first place people will be more willing to report mistakes. Shook (2010; page 68) observed that the answer that American trainees in Japan gave, to the question what they most wanted to take back with them, was invariably the same: '*The ability to focus on solving problems without pointing fingers and looking to place the blame on someone*'. Only a positive and constructive culture gives the lean implementation effort the right environment to blossom.

Avoiding employee resistance
Major change within a company almost always creates resistance. Certain people will start to show a critical attitude; other people will become scared to lose their hard won position within the firm (Black, 2007) or even their job. Sometimes these concerns are well grounded because many companies and consultants see lean as a zero-sum game in which the benefit of the company is at the expense of the workers (Arlbjørn and Freytag, 2013; Pettersen, 2009). But using lean as an excuse for downsizing is a bad idea because 'respect for people' is one of the pillars of the Toyota Production System (Marley and Ward, 2013). To prevent rumors of job losses, that send morale into a downward spiral, communication is the remedy (Black, 2007; Bhasin, 2012c; Womack and Jones, 2003). Angelis et al. (2011) are advocates of clearly communicating that there will be no lay-offs as a result of the lean initiative. According to them, everyone will feel a lot safer and people will be less susceptible to rumors being spread, which is positive for the worker commitment. Shook (2010; page 65) on the other hand, says about the job guarantee that '*no employer can credibly make such a guarantee'*. He gives an example from New United Motor Manufacturing Inc. (NUMMI) which was a joint venture between Toyota and General Motors. '*NUMMI wrote into the contract the commitment that before anyone was laid off certain steps would have been taken, including reducing plant operating hours and cutting management bonuses*' (Shook, 2010; page 65). When management is honest to the employees that they will do anything to avoid firing people they create goodwill which can be of great value during lean implementation initiatives.

Creating employee commitment
When employees of all levels are involved into the lean implementation decision making and information sharing, that creates trust (Deflorin and Scherrer-Rathje, 2012; Dora et al., 2013; Black, 2007; Chauhan and Singh, 2012; Sim and Rogers, 2009). When everyone is involved and information transparency is applied to avoid the occurrence of rumors, consistent messages are a crucial ingredient to lean success (Crute et al.,

2003). When the messages are not consistent or even opposing, employees will lose their motivation. Increasing the employee commitment can assist with subsiding the employee resistance of individual workers. Angelis et al. (2011) came up with seven work practices which are favorable in enhancing employee commitment. Those practices are; participating in improvement projects, using buffers to uncouple work stations, increasing cycle times, providing help when needed to meet production standards, job rotation to be exposed to a variety of tasks, and displaying individual output when practical. When these seven commitment increasing practices are applied, it is more likely that workers will commit to the lean journey.

Sometimes there will still be people who are very negative and critical and sometimes even refuse to cooperate. Bhasin (2012c) state that a small group of managers (about 10%) refuses to accept new ideas. According to Boyer and Sovilla (2003) three to five percent of people will be strong advocates of lean, ninety percent will be open to change but needs solid leadership and the other three to five percent will be in resisting the change needed. It is of great importance to identify those people who are resisting the change (Boyer and Sovilla, 2003). Trying to involve everyone to the process – also those who resist – is essential because missing or limited participation has a negative effect on the buy-in (Boyer and Sovilla, 2003; Cooney, 2002). When employees express their concerns over the changes or approaches, it is critical to address those concerns (Boyer and Sovilla, 2003). In rare cases there will be irreconcilable differences because there may not be a match between the needs of the individual and the needs of the organisation. In that case separation is required (Boyer and Sovilla, 2003; Czabke et al., 2008).

Train all employees for sufficient lean skills

Employees must not only be committed to the lean implementation but also need to receive sufficient training to execute their tasks in the new lean environment. Insufficient supervisory skills to implement lean, as a result of lack of training is an important barrier to lean implementation success (Bhasin, 2012c). Also insufficient workforce- and senior management skills to implement lean are high on the ranking of most important barriers to change in the research of Bhasin (2012c). He found that over 75 percent of managers in seven case studies found that there were insufficient skills among the workforce or the supervisors. Training can therefore be seen as a preventative cost which aids the lean implementation and reduces time to implement. It is important to keep in mind that work related habits are just as difficult to change as personal habits (Bhasin, 2012a). Research from Black (2007) shows, that everyone in the company must be educated in lean production philosophy and concepts, for lean principles to work. So, in order to ensure and accelerate the lean implementation, firms need to train their employees in all layers of the organisation. This finding gets supported by successful case studies (Crute et al., 2003; Shook, 2010) that provided sufficient training for their employees. Finding a good balance between training and implementation is crucial. Doing too much or too little of one of them will be harmful (Bhasin, 2012c). Liker and Morgan (2006; page 6) emphasize that point by stating '*serious learning only comes from action at the gemba – where the work is done. So drawing pictures and models of TPS is not value added*'. To, for example, successfully apply root cause analysis (5 why), employees need to be trained to analyze problems in such a way that the root causes are discovered. Only by getting at the root of a problem there is the opportunity to reduce waste and defects.

Give the workforce authority for continuous improvement

Continuous improvement can be realized by the use of Kaizen events. Farris et al. (2009; page 42) phrase the following description of a Kaizen event; *'…the Kaizen event, a focused and structured continuous improvement project, using a dedicated cross-functional team to address a targeted work area, to achieve specific goals in an accelerated timeframe (usually 1 week or shorter).'* Kaizen can result in a more positive attitude towards lean which in turn can increase employee commitment, providing to the success of the program. The participation in the problem solving during a Kaizen event can help employees get better skills and problem solving capacity. Specific, well defined goals and heterogeneity in the cross-functional team are other elements that can determine the events effectiveness (Farris et al., 2009; Angelis et al., 2011). During Kaizen events it is of great importance that the people involved have the full authority to implement their solution (Fullerton and Wempe, 2009). This ensures that problems do not pile up and also directly involves the employees in the continuous improvement mentality that is needed for true lean success. A mandate to execute improvement ideas, gives the employees the right signal that management trusts them to come up with the right solution which results in higher commitment and morale (Angelis et al., 2011). Deflorin and Scherrer-Rathje (2012) and Scherrer-Rathje et al. (2009) mention a method called the '*just do it*' room where people of different disciplines gather immediately when a problem needs to be solved. Right there and then a solution needs to be developed and planned for implementation of it. When it is impossible to solve the problem immediately, someone is made responsible for coming up with a solution at a curtain date or at the next meeting.

Keeping track of the lean implementation results

If continuous improvement is applied, it can be useful to check if the planned or expected improvements in results are realized. When workers receive information about their own results this increases the commitment and belief in the lean systems (Losonci et al., 2011; Angelis et al. 2011). Whenever a target is reached or there is some other win during the lean implementation, do not hesitate to celebrate it. Successful case studies like Scherrer-Rathje et al. (2009) use this habit of celebrating (small) wins, because it keeps everyone motivated and shows things are being accomplished. The use of a consultant, to check the lean progress, can provide the necessary external validation that your company is still on the right path (Scherrer-Rathje et al., 2009).

Fitting the compensation plan with lean

When improvements are being made and the lean implementation is being a success it is time to make the workforce profit from efforts as well. According to Black (2007) many companies feel that bonus payments are the best way to reward people. But we think that only rewarding people this way can cause the intrinsic motivation to disappear resulting from the 'crowding out' effect. This crowding out theory says that the intrinsic motivation of people will decline when money gets into the motivating equation. Black (2007) notices that the reward structure of middle management has to be changed to support the lean system design. Fullerton and Wempe (2009) found evidence that non-financial performance measures have positive effect on the financial performance of lean manufacturing. Therefore it should be wise to change the (middle management) reward system according to non-financial measures. A compensation plan that is balanced and which focuses on measures of continuous improvement, efficiency, teamwork and short-term results will create the culture where lean can survive and thrive (Bhasin, 2012a; Czabke et al., 2008).

Avoid sliding back to the old ways of doing things

An often formulated lean challenge is sliding back to the old ways of doing things. Bhasin (2012c) calls backsliding to the old ways, the single most important factor that contributes to lean failures. People are creatures of habit, so when they have the chance, they will wanted or unwanted tend to go back to the way they have always done things. (Deflorin and Scherrer-Rathje, 2012; Mann, 2009) come up with the idea to significantly change the processes and plant setup. These layout adjustments will establish boundaries to keep employees from doing things as they have always done it.

2.2.2 Industry specific people management challenges

As mentioned in the first paragraph, this paper distinguishes four types of industries. These four industry types are, mass production, processing, craft production and services. The literature study identified industry specific people management challenges in the mass production, craft production and service industry.

Mass production

Mass production employees are used to perform only one step, when introducing lean, they are suddenly required to do and understand more than one step (Deflorin and Scherrer-Rathje, 2012) so training these employees the new skills is important. Mass production workers are not used to solving problems, let alone communicating them with other departments. So involving everyone in the problem-solving process is needed. A mass producer should teach its workforce to perform a variety of skills such as machine repair, quality checking and material ordering. (Deflorin and Scherrer-Rathje, 2012). Getting mass production workers to perform multiple steps and go from ignoring problems and not getting to the root cause to handling problems immediately can be a challenge (Deflorin and Scherrer-Rathje, 2012) and should therefore be a high priority in mass producing firms wanting to apply lean.

Craft production

Whereas mass production employees need to develop additional skills, craft workers need to adapt their existing knowledge to new standardized applications (Deflorin and Scherrer-Rathje, 2012).
Craft producers are already used to solving problems, but they are not used to sharing the problems with other departments. To overcome the isolated problem solving activities, communication between departments is of great importance (Deflorin and Scherrer-Rathje, 2012). People in the craftmanship industry take pride of the broader field of tasks which they have learned over the years. Instead of being experts, people need to become generalists. The big challenge is to motivate people to work in what they think to be a less attractive environment. When improvements are made, continuously make them visual and share them with all employees to keep them motivated (Deflorin and Scherrer-Rathje, 2012).

Services

Hotels and restaurants; Vlachos and Bogdanovic (2013) show research that indicates that the number of people employed in the processes of the hotel industry can be reduced by 50%. According to them this can be done when the same person has multiple skills and thus can perform multiple tasks. This would make hotels more flexible and adaptive. Schonberger (2005) and Dora et al. (2013) both support this statement by mentioning that cross-training is an important part of lean because personnel can be more flexibly allocated among different processes.

The original seven wastes and healthcare examples.

Original Wastes	Examples of Healthcare Wastes (NHSIII, 2007)
1. Transportation	*Transportation:* • staff walking to the other end of a ward to pick up notes • central equipment stores for commonly used items instead of locating items where they are used
2. Inventory	*Inventory:* • excess stock in storerooms that is not being used • patients waiting to be discharged • waiting lists
3. Motion	*Motion:* • unnecessary staff movement looking for paperwork, • not having basic equipment in every examination room
4. Waiting (Delay)	*Waiting* for: • Patients, theatre, staff results, prescriptions and medicines • doctors to discharge patients
5. Overproduction	*Overproduction:* • requesting unnecessary tests from pathology • keeping investigation slots 'just in case'
6. Over- Processing	*Over processing:* • duplication of information • asking for patients' details several times
7. Defects	*Correction:* • readmission because of failed discharge • repeating tests because correct information was not provided

Figure 5; healthcare waste (NHSIII, 2007) as cited in Edwards et al. (2012)

Healthcare; Good communication is a challenge in healthcare. According to Suárez-Barraza et al. (2012; page 369) the greatest challenge for lean healthcare is 'to *make all the actors – technical staff, doctors, nurses, auxiliaries and administrators – aware of the potential benefits that exist if Lean principles and methods are applied in their context'*. Edwards et al. (2012) mention the importance of lay out improvements, to minimize the walking distance of healthcare personnel. Edwards et al. (2012) have included in their paper a clear and summarizing figure of the lean wastes in healthcare (see figure 5) They also describe a successful case study where patients are screened as they arrived and sorted into two groups; 1 Likely to be admitted and, 2 Likely to be discharged.
This reduced the complexity of the queuing system and reduced waiting time of all patient groups. To discovering lean improvements in healthcare, the use of value stream mapping is essential to get a clear overview of all the different process steps (de Mast et. al., 2011). Edwards et al. (2012) determine that clinical leaders find it easier to motivate staff for lean principles if the tools could be introduced in defined areas, independently of other departments or units of the organisation. From this and other findings they conclude that lean in healthcare is in the stage equivalent to the early 1990s in automotive manufacturing and yet need to embrace lean more broadly as automotive is already doing. Nevertheless the non-holistic lean initiatives in healthcare have resulted in increased productivity, lowering costs, reduced waiting times for patients, improved emergency treatment, better management and material storage, and faster cancer treatment (Suárez-Barraza et al., 2012). Also a reduction of errors and increased employee motivation and customer satisfaction are mentioned (Radnor et al., 2012).

Banking and insurance; One of the most important wastes in administrative processes is the waiting time between different administrative steps (Womack and Jones, 2003; de Koning and Does, 2008). The need to request additional or missing information from the customer is often caused by a lack of clear forms and procedures, resulting in lots of unnecessary inefficiencies and rework (de Koning and Does, 2008). It is not uncommon, for different departments or even teams, to use varying methods and procedures for doing the same things. By the use of standard operating procedures, standardized templates and clear forms and procedures, much waste can be eliminated. A successful case study of de Koning and Does (2008) provided each team with a chart showing the number of errors per employee per week, which motivated workers to reduce their errors. Value stream mapping, eliminating the seven wastes, visual management, 5S, mistake proofing and line balancing are important improvement tools in financial services according to de Koning and Does (2008). Suárez-Barraza et al. (2012) mention the case study called 'Lean Service Machine' published in 2003 in the Harvard Business Review as most significant lean example in the banking and insurance industry. The redesign of the processes of an insurance bank resulted in a 26% decrease in labour costs, together with a lowering of the costs that resulted from errors, corrections and re-work of insurance policies with 40%. This all resulted in a 60 percent increase in new life premiums in just 2 years.

Government
When trying to implement lean into government there is clear restriction formed by the administrative law regime. As Scorsone (2008; page 62) states it '*…process cycle times can be altered and or reduced. However, because the process of how a decision is made or resource allocation occurs is important, government must pay attention to this and ensure that certain processes occur under certain conditions*'. The multiplicity of stakeholders in government makes the equation more difficult. '*Efficiency and speed are only part of the value equation in government with an additional and often conflicting aspect being to ensure everyone is accorded certain rights as a citizen regardless of the cost*' according to Scorsone (2008; page 62/63). He gives the examples of successful lean efforts of a purchasing department and a library. Community development and building permits are processes that are delayed because of the nature of their regulations. Therefore processes that have the least to do with law and regulations seem the most applicable to lean application.

Company characteristic people management challenges

Organization size
Bhasin (2012c) found that small firms seem to experience less resistance from employees, but that resistance still was an important issue in small companies. Because of the higher resistance in medium and large organisations, these firms mainly need to concentrate on culture, training and widening the implementation focus (Bhasin, 2012c).
The smaller firms have more trouble with training their supervisors than medium and large companies (Bhasin, 2012c) so small firms need to be extra aware of the necessity of training.
Achanga et al. (2006) found that small and medium sized firms are more likely to have owner managers who may not have all the necessary know-how to implement lean. Another finding was that firms that are independently managed did show a feasibility of great increases in the level of ROI in comparison to owner managed firms. Because larger firms are more likely to be independently managed they have a better position in improving their ROI in comparison to the owner managed firms.
Bhasin (2012c) states that insufficient management time is mainly an issue among small companies because managers get too much additional duties.

Employee seniority
Sim and Rogers (2009) found that the longer an employee is working inside a company, the higher the resistance to the implementation of lean. Czabke et al. (2008) came to the same conclusion but added also the higher level of skills and experience to their findings. These two findings are in line with the finding of Losonci et al. (2011) that employees that are younger are more likely to accept the higher working speed

of lean systems. These findings seem to make sense because employees with greater seniority are more likely to be institutionalized and have a greater likelihood of having experienced failed initiatives before.

Shah and Ward (2003) found that there are five practices that are less likely to be implemented when plant age is higher. These five practices are cross-functional work force, cycle time reduction, JIT/continuous flow, maintenance optimization, reengineered production process and self-directed work teams. An explanation for those five practices can be that a higher plant age normally means more seniority and skills among the workers. These characteristics result in higher resistance from the workforce. Because those five practices would change the way these employees have worked all their life, it is evident that an older aged plant would experience more resistance for these practices. Three practices that are found to be positively correlated to plant age, are planning and scheduling strategies, safety improvement programs, and total quality management programs. This sounds logical because older and/or union workers like to feel secure. When there is better planning and scheduling they know what to expect. Also safety improvement programs make the older and unionized workers feel more secure. The quality management program can be explained from the fact that older and/or unionized people have in general more skills and expertise. Therefore they are more likely to enjoy increasing the quality of their output than workers without those experience and skillset (Shah and Ward, 2003).

Unionisation

Six of the twenty-two lean practices were less likely to be implemented in a unionized company. These six practices are cellular manufacturing, cross-functional work force, cycle time reduction, maintenance optimization, process capability measurements and self-directed work teams. A possible explanation for this can be that most of those six manufacturing practices directly change the work and working conditions of the worker. And because unions are there to protect the employees, the lower likelihood of implementation is consistent with this reasoning (Shah and Ward, 2003). Conti et al. (2006) found in his research about the influence of lean implementation on worker stress levels that workers that were connected to a union had significantly lower stress levels than those that where not members of a union.

Gender

Losonci et al. (2011) stated that gender can have an important impact on the process of change. If segregation of gender is embedded in an organisation, this will cause attempts of creating gender-mixed working environments or woman in leading positions to fail.

Losonci et al. (2011) describe that groups that reached target volumes were invited for a dinner by the top managers. When the target level could be maintained for a week, they received a bonus. Woman where most motivated by competing for the dinner, while males were more interested in the bonus instead of the dinner. Therefore in a muscular environment it is best to praise people and teams with money while in a feminine environment a dinner is better suitable.

Conti et al. (2006) found that woman have a significantly stronger stress reaction to lean implementation than men do, so this is a factor that needs to been taken into account when aspiring to implement lean in a company with a feminine workforce.

Relative employee costs

According to Eroglu and Hofer (2011) there is evidence that firms in larger industries (measured by total employees) tend to have more positive effect on firm performance from inventory leanness. Because the industry sizes where measured on the basis of total employees, it seems logically that the firms in these industries have a higher percentage of personnel costs. Because of the higher personnel costs these companies are more likely to benefit from the increase in employee efficiency as a result from lean implementation. Cooney (2002) states the conclusion that in some manufacturing systems, costs of employees may account for as little as 5 to 10 percent of total costs and therefore do not yield a high improvement potential. This statement affirms that companies with relatively higher employee overhead costs tend to profit more from lean initiatives than those with fewer employees on the payroll.

Previous initiatives
Scherrer-Rathje et al. (2009) explain in their case study that it is not always best to be fully transparent about the lean initiative. In this case there had been many failed change initiatives in the past. Therefore the management had to deal with a change fatigue workforce. Management used a pilot project to show that lean really worked and that created the eventual buy-in from the employees. So when a company has had failed change initiatives in the past it can be better to not be fully transparent until the positive results can be shown.

Conclusion people management challenges
Concluding this paragraph, we can state that the right company culture is of main importance when implementing lean. Management should focus more on the longer term instead of short term results. The commitment of senior management and showing this to the workforce is an essential ingredient to changing the behavior of the workforce. Not blaming people for mistakes and showing them how they are going to benefit must not be skipped in the implementation process. Employee resistance can be avoided by clearly communicating and involving everyone in the implementation process from the start. Training the workforce is a preventative costs, because good training pays great dividends in the speed and success of lean implementations. Besides sufficient training, the workforce must also receive enough authority to apply improvement ideas before having to ask for approval. Management must not forget to fit the compensation plan to financial and non-financial lean parameters. Sliding back to the old ways of doing can be prevented by making lay-out adjustments and keeping track of the lean implementation results.

Mass producers must make their workforce do more than one task while simultaneously train them to see and solve problems.
Craft workers need to adapt their existing knowledge to their new standardized environment. They need to learn to communicate the solutions to problems they found to other teams or departments. A third challenge for craft workers is to keep them motivated in a work environments that can be seen by them as less attractive.
Hotels need to focus on training their workforce to do multiple tasks because this enhances the flexibility and capacity of the hotel.
Hospitals mostly profit from lay-out adjustments to save time and walking distance. A key part of lean in hospitals is to divide clients in different groups directly when they arrive. This approach makes the queuing process simpler and shortens the waiting time. Because healthcare is still at the beginning of their lean development, applying lean as holistic as possible can give hospitals a lead to their competition.
Banks and insurance firms mostly profit from standardizing procedures and forms because this decreases the lead time and rework necessary for each application.
When trying to apply lean to government, law and regulation are the restrictive element. Governments must keep this in mind and try to start with the processes which are subject to the least amount of law and or regulations.
Size and age of firms, even as seniority and skills of employees influence the employee resistance to lean initiatives. When aspiring to implement lean, gender differences and possible previously failed initiatives need to be taken into account.

2.3 Standardization

The third of the three lean components is standardization. This lean component consists of the three lean elements; defects control, standardization and bundled techniques. This paragraph is the shortest because it has the least challenges. The low number of challenges is probably caused by the fact that most standardization is not done by people, which in itself decreases the number of possible challenges. Another reason for the low number of challenges is that there is some overlap with the first two chapters. Each challenge identified in the literature will be explained and discussed. First the generally applicable challenges will be discussed, after that the industry specific challenges. Because no company specific challenges where found, that heading is absent in this paragraph. Table 4 below already gives an overview of the challenges found in the literature that will be discussed in this paragraph.

Overview standardization challenges	
General	**Industry specific**
- Training the workforce for standardization practices; - Laying the foundation for lean implementation; - Convincing people of the benefits of standardization	*Mass / craft production* - Implementing TPM *Craft* - Getting employees to work in a standardized way *Service* - Deal with demand instability and unpredictability

Table 4; overview of the identified standardization challenges in this paragraph

2.3.1 General standardization challenges

Training the workforce for standardization practices

Defects control, standardization and bundled techniques all prevent mistakes, variability and inefficiency. To make defects control work effectively the culture has to change and the workers have to be trained. To be able to prevent mistakes, you first need to find and locate them. As mentioned in the people management paragraph, it is essential to get rid of the blame culture to be able to find, locate and solve mistakes. As also mentioned in the former paragraph, most workers are not used to look for defects or mistakes, this therefore needs to be an essential part of the lean training of all employees.
5s'ing (sort, straighten, shine, standardize, sustain) is a part of standardization and makes the workplace a cleaner and more efficient place. Therefore, these five words need to be ingrained into the company culture. Preventative maintenance work saves time and money and it a part of defects control. For preventative maintenance to work, it is important that the workforce is trained to do among other things, minor machine repairs (Deflorin and Scherrer-Rathje, 2012). Not all workers do want to receive this cross-functional training (Schonberger, 2005), so convincing them of the benefits of this training can be a challenge.

Laying the foundation for lean implementation

Establishing standardized processes and procedures is the foundation for consistent lean performance (Deflorin and Scherrer-Rathje, 2012; Liker and Morgan, 2006). According to Boyer and Sovilla (2003) the most important implementation issue is rushing to a solution without a principled base. Like a house that needs to be built from the ground up, lean also first needs a

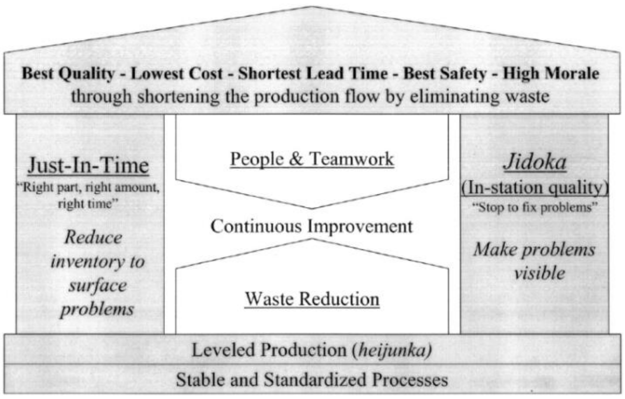

Figure 6, The house of lean (Liker and Morgan, 2006) foundation to build a house of lean that will not collapse. As can be seen from the house of lean from Liker and Morgan (2006) in figure 6, there need to be stable and standard processes and production leveling. After that the pillars JIT and *Jidoka* can start to be build. Toyota practices three categories of standardization, being design standardization (modularity, shared components), process standardization and standardized skill sets. Establishing standardization in those three categories will be the foundation of a successful lean implementation (Liker and Morgan, 2006).

Convincing people of the benefits of standardization

Some people think that the standardization of work processes will take away all responsibility and joy in their work and will only make it boring. But, when there is no standard procedure, people will have to focus all their attention to the details and the work itself. If processes are standardized, people do not have to focus all their attention to their task. By doing this, the attention of the worker can be focused more on the broader scope of the process so there is more time and energy to come up with improvement ideas (Deflorin and Scherrer-Rathje, 2012). Losonci et al. (2011) mention the benefits of this freed up brain capacity, by mentioning that when workers are treated as thinking humans instead of just 'two hands' this can develop intrinsic motivation and commitment.

2.3.2 Industry specific standardization challenges

Mass and craft production

Shah and Ward (2003) found that discrete parts industries have a higher likelihood of implementing JIT (Just In Time) and that plants in process industries are more likely to implement TPM (Total Productive Maintenance). This seems to make sense because process industries need to have their machines running almost continuously in contrast to discrete parts manufacturers who have time in between to do necessary repairs. When companies within the discrete parts industries want to get a competitive edge to most of their competition, the implementation of TPM can help.

Craft production

As mentioned in the previous paragraph, craft workers are generally not used to standardized processes (Deflorin and Scherrer-Rathje, 2012). Therefore a challenge for the craft production industry is to make people work in a standardized environment, following standardized procedures.

Service

The problem with applying lean to hospitals is that demand and activities are not as predictable and routinely as in the case of a production environment. In a case study of Edwards et al. (2012), this problem gets tackled by the introduction of so-called '*turbo rooms*'. These turbo rooms only perform standard surgery procedures on less complicated patients. So, the solution for the element of unpredictability can be to split tasks into standardized (lean) tasks, or unique and specific (non-lean) tasks.

Conclusion standardization challenges

A lesson from this paragraph is that training the employees is essential for finding and solving defects and training them to work in a standardized environment. Standardization needs to be the foundation of a successful lean implementation. Because not every employee will immediately be convinced of the necessity and benefits of standardization, this is also identified as a challenge.
The preventative action of standardizing maintenance is more widely applied among the processing

industry than in the discrete parts industry. Therefore mass and craft producers can more holistically apply lean by also implementing preventative maintenance.
Getting employees to work in a standardized production environment is the greatest challenge for craft workers because they are in general not used to standardized production.
Service firms like healthcare have to deal with the challenge of more demand instability and unpredictability than production companies.

Conclusion and discussion

Table 5 below, gives a summary of the all the general lean implementation challenges that are discussed in this chapter. As can be seen immediately, people management causes by far the most challenges in lean implementation. Resource management is second, with 5 challenges identified in literature. Of the standardization challenges, only 3 were identified.

Summary of the general lean implementation challenges		
Resource management	**People management**	**Standardization**
- Applying lean in a holistic way; - Taking the right steps in the right order; - Not exaggerating inventory leanness; - Preventing corporate anorexia; - Getting suppliers to cooperate	- Getting rid of the short term philosophy; - Establishing, maintaining and showing management commitment; - Establishing clarity, purpose and priorities; - Showing people how they are going to benefit; - Turn the blame culture into a positivity culture; - Avoiding employee resistance; - Creating employee commitment; - Train all employees for sufficient lean skills; - Give the workforce authority for continuous improvement; - Keeping track of the lean implementation results; - Fitting the compensation plan with lean; - Avoid sliding back to the old ways of doing things	- Training the workforce for standardization practices; - Laying the foundation for lean implementation; - Convincing people of the benefits of standardization

Table 5; Summary of the general implementation challenges

From this overview, the conclusion can be made that people related issues are the part of lean implementations that are most vulnerable to problems and misfits. For the workforce to accept lean, it is essential that there is clear communication about the purpose and priorities of lean. When people know what to expect, are not blamed for mistakes or defects, and are shown how they are going to personally benefit, the employee resistance will be minimized. If the workforce learns that management is strongly committed and walks their talk by using all resources available to make the workforce succeed, the employee commitment will soar. Keeping track of the lean implementation results, combined with appropriate compensation will make sure the workforce keeps motivated and does not slide back to old ways of doing things. All this, combined with sufficient training and authority for all employees will increase the chances of lean people management success significantly.
To overcome the resource management challenges it is important to combine different tools together with the lean culture and philosophy. This holistic approach has proven to be far more effective than partial implementations. Making sure that lean is not exaggerated prevents sub optimal results and corporate anorexia. For lean and especially just-in-time to work, it is of great importance to get suppliers to cooperate by delivering on the basis of JIT. The implementation steps cannot be randomly chosen, there needs to be a certain structure. Before the figurative '*house of lean*' can be build, the foundation has to be right. This foundation of lean is all about standardization, this is because lean cannot work effectively without stable and standard processes. It is important to train the workforce for standardized practices and make them realize that standardization can be in their own best interest, because a cooperating workforce is essential for every lean initiative.
Other implementation challenges are more related to certain industry types or specific company characteristics. When planning to implement lean also those specific challenges need to be taken into account.

Much lean research used for this paper is very specific or based on case studies or sometimes even one case. This makes it hard to generalize the findings of this study among countries, industries or even specific companies. The author did however try to make the results of specific studies generalizable by comparing and synthesizing the results of different studies in order to be able to distinguish between general and specific challenges. The generalization of the findings from research in different countries was done to create a broad view of the lean challenges that are identified in the literature, together with the reasoning that production and service environments within developed countries will not differ significantly.
A final remark is that the matrix (annex 1) with the nine lean components and the lean challenges has been based solely on the interpretation and knowledge of the author. The reliability of the model could have been higher when a few other experts had individually filled in the same matrix and the results where compared. Because the matrix has been used for establishing a grouping between different kinds of lean challenges this might have had influence on the arrangement of this paper. The author hopes this article has broadened the foundation for the future research on the continually growing body of knowledge on the topic of lean implementation challenges.

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Annex

	JIT	Resource reduction	HRM	Improvement strategies	Defects control	Supply chain management	Standar-dization	Scientific management	Bundled techniques	Total
Maximize the results of the lean implementation	x	x	x	x	x		x		x	7
Creating consistent lean results	x		x		x	x			x	5
Taking implementation steps in the right order	x	x			x		x			4
Not exaggerate lean		x								1
Get suppliers to cooperate	x					x				2
Not sliding back to the old ways of doing things			x					x		2
Establishing, maintaining and showing management commitment			x	x				x		3
Establishing clarity, purpose and priorities			x							1
Create a win-win situation for company and employees		x	x					x		3
Change the short term philosophy into a long term				x	x					2
Getting rid of the blame culture			x	x						2
Avoiding employee resistance			x	x			x			3
Showing people how they will benefit			x	x				x		3
Fit the compensation plan with lean		x	x	x						3
Give employees the authority to improve			x	x				x		3
Making sure employees have sufficient lean skills			x	x	x			x		4
Getting everyone involved to create buy in			x			x				2
Keep track of the lean implementation and results		x		x					x	3
Total general challenges	**4**	**6**	**13**	**10**	**5**	**3**	**3**	**6**	**3**	
Synchronizing to takt time	x									1
Training employees for new skills and solving problems			x	x				x		3
Implementing TPM			x		x		x		x	4
Reducing batch sizes	x	x								3
Implementing JIT	x	x				x				3
Integrating suppliers	x					x				2
Lowering set-up time	x	x								2
Implementing TPM			x		x		x		x	4
Motivate workers to do standardized tasks			x				x			2
Creating standardized processes							x			1
Teach employees to communicate improvement ideas			x	x						2
Adapting existing knowledge to new standard applications			x				x			2
Getting everyone to work together			x							1
Getting everyone to do multiple tasks			x					x		2
Law and regulations can hinder lean in government	x	x				x				3
Total industry specific challenges	**6**	**4**	**8**	**2**	**2**	**3**	**4**	**2**	**2**	
Small firms are less likely to achieve lean success	x					x				2
The effect of size is stronger in production than service firms			x							1
Small firms are restricted by their funding and leadership	x		x							2
For small and medium firms it is hard to dictate lean supply	x					x				2
Employee resistance is stronger in medium and large firms			x							1
Small firms have more trouble with training supervisors			x							1
Small and medium firms are more likely to lack know-how			x							1
Low competitive environment can result in lower motivation		x	x							2
Unstable demand makes lean less applicable	x	x								2
Older and more skilled employees tend to have higher resistance			x							1
Unionization can lower the likelihood of impl. some lean tools		x	x					x	x	4
High plant age can lower the likelihood of impl. some lean tools	x	x	x					x	x	5
Taking gender differences into account with compensation			x							1
Previous failed change initiatives lower workforce motivation			x							1
Total company specific challenges	**7**	**4**	**11**	**0**	**0**	**2**	**0**	**2**	**2**	

Annex 1; Lean elements and challenges matrix