Notre Dame University
Faculty of Business Administration & Economics
Graduate Division

Lean Manufacturing: Implementation and assessment

Case of "Algorithm Pharmaceutical Manufacturers" s.a.l.

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree
of the Master of Business Administration
(M.B.A.)

MARIANNE KHLAT

Supervisor : Dr. Atef Harb
Reader : Mr. Rabih Osta

NDU – Lebanon

2013

Approval certificate

Lean Manufacturing: Implementation and assessment

Case of "Algorithm Pharmaceutical Manufacturers" s.a.l.

BY

MARIANNE KHLAT

Approved

Name and Signature: Dr. Atef H Harb 16/7/2013

First Reader: Dr. Atef Harb

Name and Signature: ______________ 2/8/2013

Second Reader: Mr. Rabih Osta

Signature: ______________

GRADUATE DIVISION
Faculty of Business
Administration
and Economics

Assistant Dean, FBAE, Dr. Roy Khoueiri

Grade: B+

August 23, 2013

Date

DECLARATION

I hereby declare that this thesis is entirely my own work and that it has not been submitted as an exercise for a degree at any other University.

MARIANNE KHLAT

ABSTRACT

Lebanese industries are growing so fast and expanding their businesses. They should know how to manage their time, inventory, labor, quality and all the other production factors in order to increase productivity and output while reducing different types of wastes.

For that, lean manufacturing was adopted by many companies across the globe in order to try to reduce the wastes as much as possible.

Lean is a manufacturing strategy aiming to reduce the inventory and to gain more profits while getting a better quality of the goods delivered to the customers.

"Algorithm Pharmaceutical Manufacturers" is a Lebanese industry that is trying to implement lean in its production strategy.

The aim of this study is to understand to which extent lean tools are implemented in the company (H1) and to know if a relationship exists between the application of these tools (Kaizen, JIT, TPM and standardization) and the effectiveness of the productivity (H2). The research will be done via a five-point likert scale questionnaire related to "Algorithm Pharmaceutical manufacturers". It will be addressed to employees from different levels of the organization.

The answers were analyzed by using a linear regression and a Chi-square test in "SPSS" and by conducting a focus group and a depth-interview with employees. Results showed that lean tools were implemented but not fully so hypothesis H1 is partially proved.

In addition, in the team members' opinion, a relation exists between the application of lean tools (especially the standardization and Total productive maintenance) and the effectiveness of productivity (significance: 0.000-0.309) but managers don't believe in this relation according to the results (significance: 0.212-0.653). Therefore, hypothesis H2 is significant in the team members' opinion more than in the managers'.

Key words: Lean manufacturing, Kaizen, Total productive maintenance, Just-in-time, standardization, 5S, effectiveness

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACKNOWLEDGMENTS

I would like to thank all the people who made this thesis possible.

First, I would like to express my deepest appreciation for my supervisor, Dr. Atef Harb for his guidance, motivation and support. His expertise in the lean manufacturing concept improved my research skills and guided me for a new way of thinking.

Second, I would like to express my very sincere gratitude to Mr. Rabih Osta for his feedback and comments.

I can't but thank my colleagues in "Algorithm" from the upper management to the lowest level of employees who gave me some of their time in filling the survey and meeting during focus group and depth-interview.

It would not have been easy to complete my Thesis without the support of lots of people around me mainly my husband, my father and my mother who were always there encouraging me with their best wishes even in the hard moments.

Finally, I take this opportunity to thank my one-year-old little boy who offered me his smile, laughter and love whenever I was overwhelmed with all the data collection and the thesis writing.

Table of Contents

Chapter 1

Introduction

Industries around the world manufacture different types of products and deliver them to the customers in order to satisfy the market need. These products, from different sectors, pass through a whole process since the receipt of the raw materials from the supplier, going through all the manufacturing, packaging, control and testing stages until the delivery of the final good to the customer.

Lebanese industrial sector, which constitutes around 16% of the Lebanese economy, is wide and very diversified from the textile, plastic, furniture, paper, marble, wood, pharmaceutical, food and beverages and other sectors. It plays an important role in the Lebanese economy.

The following pie shows the repartition of the industrial companies by type of activity as of February 2012.

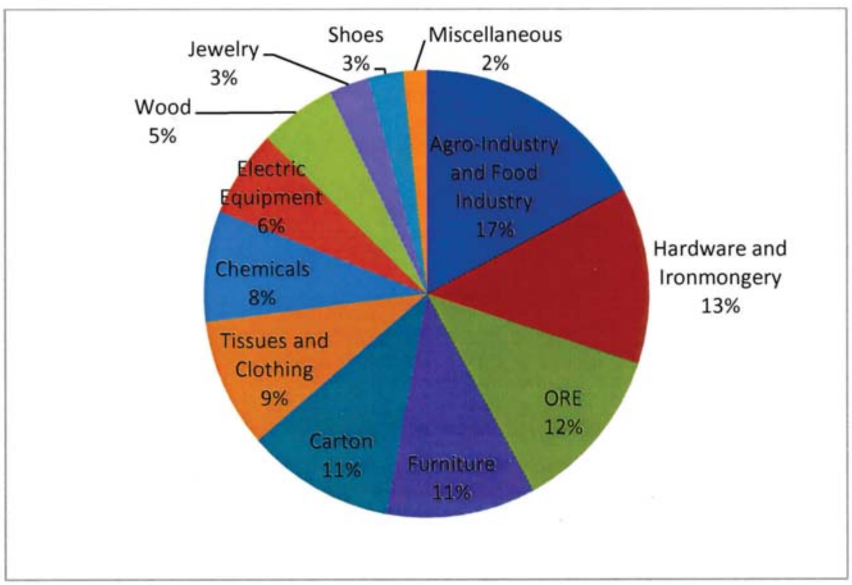


Figure 1: Repartition of Industrial Companies by type of activity as of February 2012

(The Directory of Exports & Industrial Firm in Lebanon, 2013)

Lebanese industries can be classified into different categories depending on their productivity which is also linked to the strategy they are adopting; some of them are facing difficulties trying to manage their inventory, labor and time while keeping the good quality of their goods. Whereas, other Lebanese industries could overcome these problems and increase their profitability.
Lots of authors described "lean manufacturing" as a strategy aiming to decrease waste, costs and increase productivity of the firm. This concept evolved over the years and many companies across the globe tried to implement it while others preferred to adopt the traditional manufacturing process and resist change.
It generates a production cost reduction, manufacturing time cycle decrease, inventory reduction, higher quality, flexibility, higher profits and a cash flow improvement.

In this Thesis, we will define the lean manufacturing strategy, stating its origin and concept, then describing all the principles followed in order to achieve the best productivity for the firm while reducing the wastes. These wastes will be detailed at a later stage in chapter 2.
Then, we will develop the lean manufacturing methods and tools explaining their advantages in improving the work and the profitability of the Lebanese industries.
For a better treatment of the subject, we will go through the Lebanese industrial sector stating its position in the Lebanese economy and the impact that it can have on the good manufacturing practice inside a local industry and on the global economy of the country.
For this, we will take the case of a Lebanese industry that has its plant in Lebanon, manufactures locally then delivers the products and services to the customers in Lebanon and in several countries across the globe.

"Algorithm" is a Lebanese pharmaceutical industry that manufactures, packs and markets several types of medications to clients in order to provide good health and well being for patients.
Employees at "Algorithm" work hard in order to deliver the best quality of the medication to the patients while reducing the cost needed to produce the goods. The products pass through a long and complex process before it is delivered. They are either

formulated by the research and development department inside "Algorithm" or derive from licenses of reputable international companies.

"Algorithm" is based in Lebanon. It produces medications for different therapeutic areas like endocrinology, urology, cardiology, neurology and gynecology.

In 1961, the plant was built in Lebanon as "Charles E. Frosst & Co. (M.E.)" s.a.l. and operated until 1989 as a subsidiary of Merck & Co. Inc. (MSD).

Later, the ownership was transferred to "Al Ghorayeb" family and shareholders of "Droguerie de l'Union". Then, "Algorithm" became the new name of the company.

Nowadays, “Algorithm” manufactures several pharmaceutical products and is expanding in this field with a high number of medications.

Its quality system is based on GMP (Good Manufacturing Practices), GLP (Good Laboratory Practices) and complies with ISO 9001:2000 requirements. (Algorithm Pharmaceutical Manufacturers, 2011)

Based on the problems encountered in the production cycle, we will conduct a study in order to assess lean implementation in "Algorithm"; the wastes that are occurring inside the Lebanese industries are reducing the productivity leading to higher cost and to lower quality of the finished goods delivered to the clients. These wastes have a negative effect on the performance of these firms, their profitability and their output.

In addition, higher expenses are generated, more defects are obtained and the production cycle time is long leading to a delay in the delivery of the products.

Therefore, the cost is too high comparing it to the effectiveness of the production.

The research questions that will be addressed throughout the thesis will treat the following issues:

- RQ1: Do managers and team members inside “Algorithm Pharmaceutical Manufacturers” know about lean manufacturing principles?
- RQ2: Are lean tools applied inside the industry? How is this assessed from different levels of employees?

- RQ3: Do lean tools have a positive impact on the productivity of "Algorithm" Lebanese industry?

For this, two general hypotheses will be tested trying to answer the research questions:

- H1: Lean manufacturing tools are seen as an efficient management tool more and more adopted/implemented in the production cycle.
- H2: Lean manufacturing tools will increase the productivity by reducing waste.

The aim of this study is to identify to which level lean manufacturing is being implemented in "Algorithm Pharmaceutical Manufacturers" especially in its production department. This will be assessed on the different employees' levels (Managers / Supervisors and team members) for better performance while reducing the costs generated from the production cycle.

In addition, we will try to identify if a relation exists between the application of lean tools and the productivity of the company.

The research is crucial in order to identify the wastes encountered in such industries and try to increase the profitability of Lebanese industries while delivering the best quality of products for the end consumer.

In this study, a survey will be addressed to some employees in "Algorithm" filling different positions in the company in order to understand to which extent lean strategies are implemented and to assess its productivity.

Following this, we will conduct a focus group and a depth-interview to analyze the results generated by "SPSS". Finally, we will conclude by the discussion of our findings and we will propose some recommendations for improvement and for a better profitability.

Chapter 2

Review of literature

After introducing the thesis subject in Chapter 1 and stating what will be discussed in the upcoming pages, this chapter will detail the lean manufacturing concept explaining how it started and how it evolved through the years for a better implementation.

Then, we will go through the lean manufacturing principles, and the methods and tools used while applying this strategy in the firm.

At a later stage, we will discuss the Lebanese industrial sector for a better understanding of the need to improve the operations inside the Lebanese industries in order to get a better productivity. In addition, we will explain the cGMP principles for a better understanding of the quality system inside "Algorithm".

Lean manufacturing is a strategy that aims to reduce the different types of wastes encountered in the production cycle thus generating higher profits, better quality and customer value and this in the different stages of the value stream.

Lean manufacturing, was named differently by many authors over the years; "lean enterprise", "lean production", "agile manufacturing", "just-in-time manufacturing", "continuous flow", "synchronous manufacturing" or "Toyota Production System".

The benefits of the production cycle are increased and this through a reduction of the work needed, of the wastes encountered, of the inventory in stock, of the capital needed and of the resources to be used. (Tinoco, Implementation of lean manufacturing, 2004)

With lean, there's a complete shift of the structure of the company from independent and vertical departments to horizontal departments and better flow of information.

It works on different levels from customer service, production, quality and this since the receipt of the raw materials from the suppliers to the final delivery of the products to the customer.

It aims at reducing the non-added value activities and redirecting the non-added value activities to added-value activities.

Lean can be applied to all types of industries and services. It is not a short-term strategy but a long-term vision of the overall corporate production process and strategy. (What is lean - History, 2009)

Wanitwattansakosol & Sopadang (2012) reviewed lean manufacturing as a way to reduce waste and lead-time. They defined waste as a non-value added activity created by the human. (Wanitwattansakosol & Sopadang, 2012)

Vu (2007), in his project, defined lean manufacturing as a way to reduce waste, increase cost saving and profitability of the firm. He focused on the importance of having lean as a part of the corporate strategy while involving management and personnel participation. Lean will improve customer satisfaction thus generating corporate growth.

According to him, a company should look at all aspects of the production cycle from its start till its end and try to identify the wastes that occur at the different stages of the product life cycle. (Vu, 2007)

2.1. Origin

Lean manufacturing was first integrated by Henry Ford and his right-hand-man Charles E. Sorensen in 1913 and they created the flow of production, also known as mass production, by moving interchangeable parts.

Ford and Sorensen arranged resources like people, equipments, tools and goods in a continuous system for the manufacturing of the Model T automobile.

Ford tried to group the manufacturing steps into a sequence of operations using special-purpose equipments. This made the work faster and the quality of the product better. Consequently, the performance of the machines was improved but Ford couldn't deliver a variety of products to customers and was left with only one type of goods as no changeover was done during the production cycle.

Delivering a unique product, Ford concept was not successful as customers asked for diversification of goods and services.

Afterwards, many industries tried to elaborate and ameliorate Ford's strategy and expand their research in order to get a faster production cycle with better performant equipment that will help reducing costs. In addition, the waiting time between the different stages of the production was long and information was not easy to manage.
Lots of industries didn't know how to adopt Ford's principle in their production cycle. (A brief history of lean, 2012) (What is lean - History, 2009)
Ford's concept was then modified and replaced by job rotation and framework in order to get better quality and more involvement of the employees in the process. (Kovacheva, 2010)
According to Kovacheva (2010), this new model changed the concept of management thinking. This is true since the whole concept of operations inside the industries was modified in order to be more flexible to the market demand and to satisfy the customer need while delivering the best quality of products and services.
Then, Japanese engineers from Toyota, Taiichi Ohno and Shigeo Shingo, reviewed Ford's concept and invented the "Toyota Production System" in 1930. They tried to adjust the production capabilities to the batch size ordered by the customer while delivering a variety of products and a continuous work flow. They also introduced right-sizing machines to ensure the quantity needed, self-monitoring machines to ensure the best quality and they pioneered quick changeovers.

The "pull system" was then established whereby each step of the production will notify the following step of the materials needed to keep the flow of materials smooth and the work performed faster and easier. The equipment will be able to produce small quantities of goods thus generating less costs and inventory and a better flow of the information needed. (History of lean manufacturing, 2012) (Lee, 2003)

Nowadays, Toyota is succeeding in many countries in the world and this by applying lean manufacturing tools.
Companies should adopt the same path and they should train their leaders to know how to apply lean in their tasks for better performance of the firm and this in different sectors and departments such as manufacturing, logistics and distribution, services, retail,

healthcare, construction, maintenance, and even government. (What is lean - History, 2009)

2.2. Lean principles

After introducing lean manufacturing as a way to reduce wastes and to improve company's profitability and after explaining the origins of this concept and how it evolved over the years, we will detail the principles for a lean manufacturing strategy to succeed and to be efficient.

According to Kovacheva (2010), five principles need to be implemented in all organization's levels and they are based on a complete transformation of the business strategy (Kovacheva, 2010). She emphasizes on the fact that even the knowledge-based activities require the usage of lean thinking in their job. This is true since a strategy needs to be applied in all the organization's operations for a better performance and coordination among the departments. In addition, this will create value inside the company and will form the "lean enterprise".

Kovacheva (2010) developed the five principles as follows and as represented in Figure 2:

1. Identify value: this principle is related to the knowledge of customers' needs. It needs to be applied in all organization's departments in order not to encounter waste during the production cycle.
2. Map the value stream: this principle refers to the elimination of all non-value added steps for each product family and service. This is done by product definition, information management and physical transformation.
3. Create flow: the flow becomes continuous and smooth in the remaining value-added steps for a better communication among departments and for a safe movement of the information and the materials between the different stages.
4. Establish pull: The client will ask for the product or service when needed thus reducing inventory cost.

5. Seek perfection: wastes are eliminated, inventory is reduced and work is faster thus reducing time lag and the amount of information needed. (Lean Methodology) (What is lean - History, 2009) (Kovacheva, 2010)

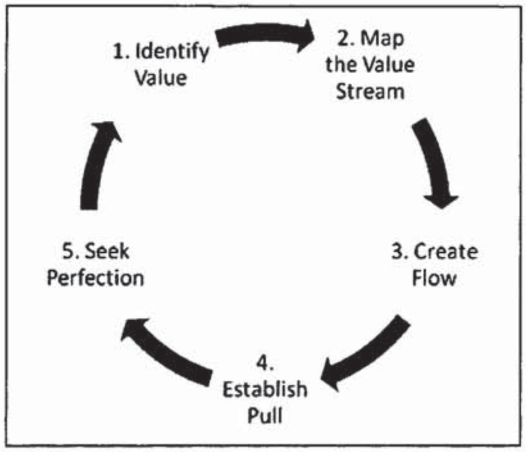


Figure 2: Lean Principles

(What is lean - History, 2009)

So based on these principles, lean manufacturing needs to adopt these stages for a better effectiveness. In the following part, we will detail the lean wastes which constitute the major problem of our thesis and that need to be eliminated as much as possible for a better productivity.

2.3. Lean wastes

Lean manufacturing surely needs to follow principles for better results but this is not enough for the company's growth without eliminating the wastes that occur in the different stages of the product life cycle. Lots of companies suffer from an increase in the costs encountered due to wastes that occur at several levels in the firm and that reduce the profitability.

Shetty, Ali & Cummings (2010) conducted a research on 143 lean companies in order to study the benefits of the lean implementation strategy in the elimination of waste. They identified that lots of waste occur in the production cycle. (Shetty, Ali, & Cummings, 2010)

Lean wastes have been developed by lots of authors who studied lean manufacturing and who tried to identify the reasons behind the high costs of production.

Tinoco (2004) described 7 types of waste in his research paper in order to develop the value stream mapping and to identify at which stage of production these wastes are occurring. He tried to understand the current state of operation and give recommendations depending on how much waste we can control throughout the process and this by developing a future value stream mapping. (Tinoco, Implementation of lean manufacturing, 2004)

.

According to Vu (2007), he identified waste as using more resources than required leading to more costs and to less customer satisfaction. Therefore, by reducing these wastes, the productivity of the company will improve. (Vu, 2007)

Figure 3: Types of waste

(Introduction to Lean and Waste Course, 2000-2013)

According to Miller, Pawloski, & Standridge (2009), lean avoids overproduction or under production in the operations. In addition, lean helps reducing the lead-time between stages; this way, inventory is minimized and wastes are decreased. (Miller, Pawloski, & Standridge, 2009)

Wanitwattansakosol & Sopadang (2012) also discussed the benefits of the reduction of the lead-time while implementing lean manufacturing. According to them, this will accelerate the customer feedback and the quick response to any market comments thus leading to a faster satisfaction of the customer. (Wanitwattansakosol & Sopadang, 2012)

These wastes are described by several authors as follows:

1. Waiting: every product needs a certain time before it can be moved to the following step and this is due to quality inspection and testing, space between stages which can delay the movement, flow of materials and information or other non-value added activities. Lean manufacturing aims to reduce the waiting stages between two consecutive processes for a faster operation.
2. Overproduction: when this waste is encountered in the production cycle, it means that non-required items are manufactured leading to high cost and bigger inventory as these items are stored expecting their requests from the customer.
   This prevents the smooth stream of materials and leads to lower quality, higher space storage and more elevated amount of imperceptible defects.
3. Inventory: Excess inventory consumes a lot of time and needs a bigger storage area thus increasing the cost of production.
4. Over Processing: This type of waste is related to the fact that industries may purchase more sophisticated equipment for their operation than needed. The machines may not be required to perform complex procedures and the machine could be more expensive than the simple one. This will result in a massive usage of the equipment trying to cover the money spent on the original purchase.
5. Defects: defect will lead to a rework operation or a destruction / rejection of the units produced; consequently, there's a waste of products and more time is spent to perform a rework operation on the defective units. In addition, we would have lost the time that we already spent on manufacturing the original units. Therefore, costs will be higher, re-inspection will need to take place and inventory will increase involving lots of departments and lots of additional work.
6. Transportation: This waste occurs when operators don't move the products from one location to another with care and focus. They mishandle the units produced causing

defects or even destruction of the product. This will lead to an increase in the cost of the production as new units need to be produced or the defective units need to be reworked, otherwise the delivery of the product won't be in the full quantity requested by the supplier.

7. Motion: This waste includes movement of the employees in the departments and among the different stages of the production in addition to health and safety issues. One should be focused on the task when dealing with machines especially the ones with sharp edges in order not to lead to any kind of accident that can alter the employee's health and delay the work because of shortage of operators.

2.4. Methods and tools

Wastes need to be eliminated from the product life cycle in order to have a smooth production and an efficient process. For this, companies adopt one or several tools and methods to assure the reduction and the elimination of these wastes.

Wanitwattansakosol & Sopadang (2012) found out that companies need to judge which lean tools to adopt in their strategies in order to meet their expected targets and goals. (Wanitwattansakosol & Sopadang, 2012)

Nordin (2010) discussed lean manufacturing as a way for success. It is not applicable by all industries but when it is implemented, it requires a complete change of the whole corporate strategy. A case study was done on 60 Malaysian firms and found out that readiness for change, team development, leadership support, training, effective communication and empowerment are the major success factors for lean implementation. (Nordin, MD Deros, & Abdul Wahab, Relationship between organizational change and lean manufacturing implementation in Malysian automative industry, 2010)

These methods and tools are developed by lots of authors. (Tinoco, Implementation of lean manufacturing, 2004)

Engum (2009) studied the implementation of lean manufacturing on 64 newspaper printers in the United States and found out that people are familiar with this concept, but they don't know how this strategy can be adopted for a better productivity of the firm. This led to a rate of 17% of firms who could implement lean manufacturing as managers focus more on costs rather than on ways to increase efficiency.

She concluded that each company can use the lean manufacturing tools depending on the available resources and on the management and leadership skills. In addition, lean implementation needs to promote change inside the organization in order to enhance effectiveness and to help employees to adapt to the newly adopted strategies. (Engum, 2009)

Kim (2002) also assessed lean manufacturing concept in Austin in the construction field and found out that lean helps improve human relationships for a better communication so a better cooperation among departments. In addition, job satisfaction is enhanced. (Kim, 2002)

Maez (2008) found out that determining which tool to use is very crucial because they need to be applied in a proper way for the firm growth. The author studied the combination of lean manufacturing and six sigma for a better quality and for the company's improvement.

According to him, lean focuses on eliminating wastes inside the company thus focusing on quality and on reducing product defects. As for the six sigma's, it reduces the variation in the process. So a combination between these 2 methods is essential for a better productivity. (Maez, 2008)

2.4.1. Just-in-time

In order to operate in a faster way and to decrease the time needed between the steps, operations should be performed using the quantity needed, in the time frame required while assuring the best quality of product for the customer. This way, wastes of waiting will be reduced.

As per the literature, we can classify this tool into Just-in-time production, Just-in-time purchasing and Just-in-time transportation.

2.4.2. 5S Visual Workplace (5S / Visual Workplace Handbook - Building the foundation for continuous improvement)

5S is also known as Visual Factory or Visual Management. According to Tinoco (2004), this tool assures the continuous improvement of the company by ameliorating the cleaning and housekeeping performance. Therefore, health and safety measures are provided for the employees and the information is better organized for a better communication among departments and for a better performance of the firm.

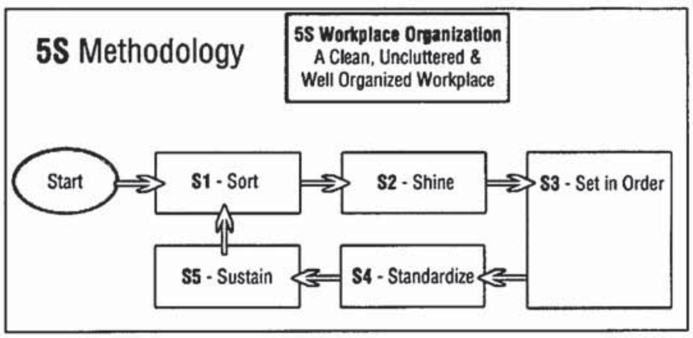


Figure 4: 5S Methodology

(5S / Visual Workplace Handbook - Building the foundation for continuous improvement)

This tool helps reducing non-value added activities and this in several areas of the production cycle. 5S improves the quality of the product by rejecting non-needed tools and materials, reducing the mistakes linked to an unorganized environment, decreasing the cost of the machines and tools handled and arranging the workplace so employees feel at ease during working hours. This way, the wastes linked to transportation can also be reduced as employees can move easier in the plant without causing defects of mishandling of the units produced.

5S methodology can be detailed in 5 steps as per Figure 4 above:

The first step of the 5S tool is "sorting" whereby all useless items are destroyed from the production cycle, after being stored for a period of time as per the company or regulation requirements. When no member asks for them, they are to be discarded.

Following that, comes the "shining" step where the workplace has to be kept clean, net and free from any contamination to avoid any defect in the product and therefore to reduce the high costs that can be generated from such a disorder. This task is the responsibility of every employee inside the company so that all equipment and floors need to be kept clean at all times. The housekeeping team also follows a schedule for cleaning and everyone has to adhere to the preventive maintenance requirements set by the company in order to ensure the good performance of the equipment.

The third step in the 5S tool is "Set in Order" where the information is analyzed in order to find solutions for eventual problems by reducing the several types of wastes that can encounter in the production cycle. In here, employees are requested to keep everything in its place with dedicated tools for each area in order to control the process and not to lead to falsification or cross-contamination.

Then, comes the "Standardize" step where each operation needs to be performed in the same way overtime and by all the employees involved. Standard operations procedures are established and need to be followed.

Standardization is adopted within "Algorithm Pharmaceutical Manufacturers" as SOP ("Standard Operation Procedures") where each section has a record of SOPs identified within the operations they perform. This helps employees to follow the same process according to written guidelines in order to reduce failures and to diminish the defects generated. This is guaranteed by visual control from managers and supervisors responsible of the line; they guide their subordinates and train them in their daily tasks.

The last step of the 5S tool is the "Sustain" step in order to get a better productivity and a continuity of the good work. This is assured by a continuous training of the employees on their tasks so that the good results are maintained in the long run. Managers should ensure the best practice of the operations and should inspect the work, through internal and external audits, in order to find if any gap exists and to try to solve the problems encountered for improvement and for better productivity.

2.4.3. Standard or Standardized Work

According to Tinoco (2004), standard operation sheet can be applied in order to eliminate unnecessary inventory by the first line supervisors. This will also help the operators to reduce defects.

The production steps, since the receipt of the raw materials to the delivery of the products passing through all the manufacturing and packaging steps, should be executed according to written standards as per the regulations and the quality control system adopted by the company.

Tinoco (2004) divided the standardization tool into three elements:

- The "Cycle time" which is the time needed for the employees to produce one unit of the product.
- The "Standard operation routine" defines the order in which operations need to be performed for a better sequence.
- The "Standard inventory" defines the minimum quantity of work-in-process inventory needed to perform a certain task in the production process.

2.4.4. Total Productive Maintenance (TPM)

According to Tinoco (2004), increase of the plant capacity can be done through TPM. He stated that the total productive maintenance tool ensures a better performance of the equipment by maintaining them in a good condition thus reducing the risk of troubleshoot and failure. When the machine is performing well, no downtime failure occurs and the waiting time for the repair is shortened. This way, the production cycle becomes faster and the quality of the units produced are not affected by mechanical problems.

Tinoco (2004) identified several wastes that can be encountered if the preventive maintenance is not done in the right way: long time needed for the setup of the equipment, time lost on the repair of the equipment if a failure of any type is encountered, losses caused by misadjusting the speed of the machine, defective products during setup phase or during the process run.

This tool has three major objectives, after working on the original setup of the machine so everything is in its place and well installed:

- "Zero Product Defect".
- "Zero Equipment Unplanned Failure".
- "Zero Accidents".

2.4.5. Load Balancing

Lean manufacturing aims to reduce the batch size of the production to meet the customers' demand on time; this way, and through the load balancing tool, the lead time needed is shortened thus accelerating the process and eliminating all non-value added activities leading to less costs and less wastes. Therefore, fewer products are manufactured and this in a shorter time. (Level Load Balancing, 2013)

2.4.6. Pull & Kanban Systems:

According to Tinoco (2004), time waiting between stages can be eliminated through kanban method. Toyota introduced the Kanban tool in order to eliminate wastes encountered from waiting and excess inventories. This tool is represented by a rectangular vinyl card where all the information of the current stage are stated along the way to finishing and which parts are needed for the next stage in order to reduce the inventories and to respond quickly to the changes in the process. Coordination needs to be established between the different steps for a good functioning of the tool. This way, performance is ameliorated and the company can adapt to change in a more efficient way.

Tinoco (2004) described different types of Kanban system adopted worldwide:

2.4.6.1. "Withdrawal Kanban": this type of Kanban allows the movement of parts from one stage to the subsequent one.

2.4.6.2. "Production Ordering Kanban": it determines the type and amount of units that the previous step must produce.

2.4.6.3. "Signal Kanban": this type indicates the lot in the stamping stage and a tag is placed. Two types of Signal Kanban are used:

2.4.6.3.1. "Triangular Kanban": It provides all the information needed to do a process (e.g. in order to produce A, we need to use B, and B is placed in the Store-E).

2.4.6.3.2. "Material requisition Kanban / Rectangular Kanban": B must be in Store-E in order to produce A.

2.4.7. Work Cells

This tool is characterized by the fact that each step needs to be completed before the next one is initiated in order to better organize the work, to reduce the in-process inventory and to reduce the labor costs as different machines work simultaneously. This way, quality is improved as inspection of errors and defects can be detected more easily because one product is produced at a time.

Work Cells can be described as follows:

2.4.7.1. "Product/process family focus": the machines are organized depending on the products dedicated for such a use.

2.4.7.2. "One at a time production": one piece is created at a time and the next one is produced after the previous one is completely done.

2.4.7.3. "Flexible output levels": the quantity of the units produced is adjusted to the customers' order. This leads to a more flexible operation.

2.4.7.4. "Operator multi-tasking": employees perform their tasks on similar machines simultaneously in order to produce one unit.

2.4.8. Rapid Changeover (SMED)

According to Tinoco (2004), a quick changeover (SMED: single minute exchange of die) is a major progress for the firm to improve and to increase its productivity.

This lean manufacturing tool aims to fasten the way the changeover is performed on the equipment before initiating the production of a certain item. It will help reduce non-value added activities and the high costs generated from the waiting time needed before the machine is ready.

A quick changeover targets a more flexible environment so that products are grouped by family for a simpler and an easier work. In addition, less steps of changeover are required to make the process even faster. (Abbruzzese)

2.4.9. Mistake-Proofing (Tague, 2004)

Tague (2004) developed the lean manufacturing tool known as mistake-proofing and called "poka-yoke" in Japanese.

Lots of errors can occur in the product cycle and this since the receipt of the raw materials from the suppliers to the final delivery of the product to the customer going through all the stages of manufacturing, production, packaging and testing. These errors can be related to customers, employees or any other part of the cycle. In addition, these errors can be minor, major or even minor leading to major ones if not treated the correct way.

The aim of this lean tool is to try to reduce these errors as much as possible and to prevent them from happening. It also helps find solution for these problems as soon as possible in order not to alter the production cycle and the quality of the units produced.

For this, employees, especially the managers, should review the whole production process and try to identify the errors that occurred then try to identify the source of this error.

At a later stage, they should find ways to prevent the errors from happening and this by a complete elimination of the source of the error or by a change in the process, which prevents a similar problem from occurring in the future.

Furthermore, employees can find ways to predict these errors from happening in the future, either by live inspection on the process or by a close monitoring of the employees or of external parties on the tasks performed.

2.4.10. Kaizen

Kaizen or "Continuous improvement" is a lean manufacturing tool aiming to involve all the employees in the operation process and this after providing them with the adequate training and coaching program required in order for them to perform their tasks in the correct way.

The company needs to continuously develop the skills of these employees and to empower them in the decisions for a better elimination of the wastes.

Vu (2007) identified that employee input is efficient in increasing responsibilities thus generating higher commitment and improving efficiency. Employees will be more involved and more motivated. (Vu, 2007)

2.4.11. Production Smoothing Method / Hejunka

This tool plans to modify and adjust the client's request by volume and variety while maintaining the same volume of production for a certain period of time. It will help reduce waste by eliminating some work-in-process inventory and the labor time needed to perform a task.

2.4.12. Value Stream Mapping (VSM) (Rother & Shook, 2009) (Magnier, 2009)

Many authors developed the value stream as a visual representation of the whole production process from the time the order is placed until the final delivery of goods and services to the customer passing through all the required steps. It also includes all the flow of processes and information that occur meanwhile.

Rother & Shook (2009) and Magnier (2009) developed that tool, aiming to identify the flow of the materials and the information inside an organization. This will help eliminate all non-value added activities, emphasis on the value-added activities in the process and identify waste while trying to find solutions for improvement. Costs will be reduced while maintaining the high quality of the products to be delivered to the customer.

The Value Stream mapping tool contains four steps that need to be followed for a good application of the tool:

2.4.12.1. Choose the product that we need to study and define its characteristics.

2.4.12.2. Create the "Current State" Value stream mapping (CSVSM). In here, we need to define its scope, the steps to be performed and the different stages of the production process and the delays that may encounter in the cycle. In addition, we need to choose which symbols to use as per Figure 5 and collect as much information as needed in order to illustrate a representative map and to identify at which stages of the production the wastes are occurring.

2.4.12.3. Create the "Future State" Value stream mapping (FSVSM).

2.4.12.4. Establish a plan to make the FSVSM the CSVSM. At a later stage, a meeting is held with all stakeholders involved in the process where discussions will take place to evaluate the situation.

Value stream management is the tool that guarantees the good application of the different tools, detailed before, in order to organize and ensure the adequate implementation of lean manufacturing inside the company.

The aim of the value stream illustration is to identify all non-value added activities and reduce them as much as possible in order to reduce all non-value added costs.

Several symbols are used while developing a value stream map as shown below.

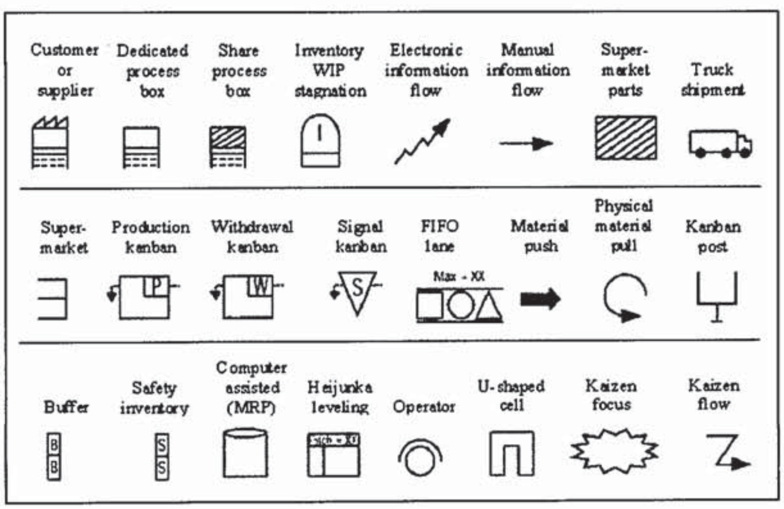


Figure 5: Value Stream Mapping Symbols

(Grout)

The following picture shows an example of the value stream map.

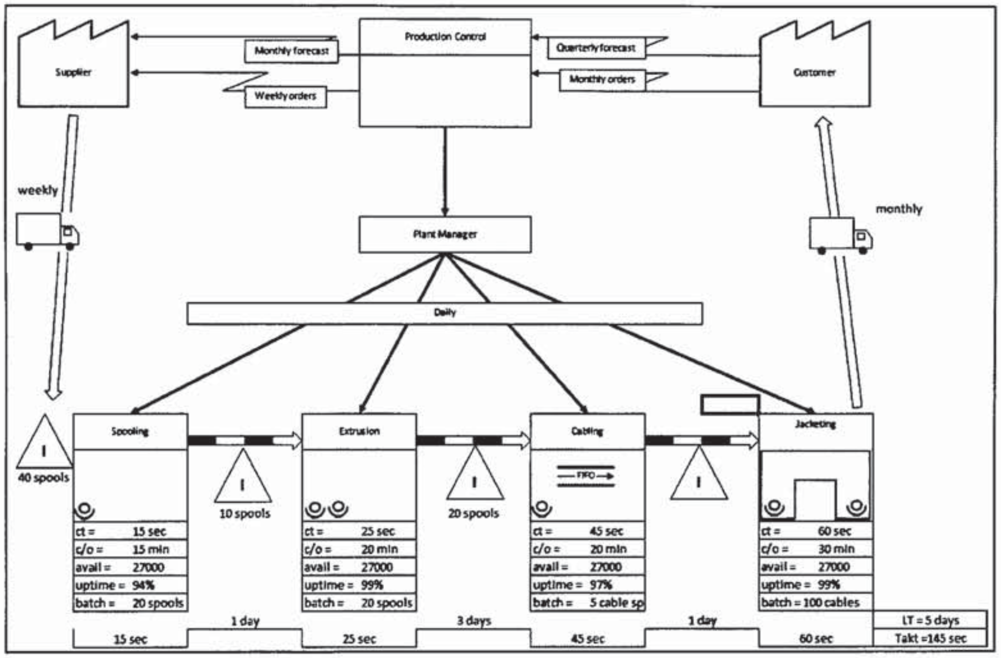


Figure 6: Example of value Stream map

(Value Stream Mapping Tools, 2012)

2.5. Lean manufacturing implementation steps

(Lee, 2003) (Tinoco, Implementation of lean manufacturing, 2004)

After detailing the lean manufacturing tools that exist and that several authors discussed in their studies, we will go through the lean manufacturing implementation around the world in the adopted strategies for improvement.

Marin-Garcia and Carneiro (2010) studied the implementation on 128 Spanish companies and found out 81 practices of lean. (Marin-Garcia & Carneiro, 2010)

Lila (2012) studied the lean application on 76 factories in Thailand and concluded with a 61.8% rate of automotive manufacturers companies applying the lean manufacturing strategy mainly in the departments linked to the production process. The knowledge of lean was more noticed in experienced and educated personnel rather than in lower degree employees. He concluded with the fact that awareness of these principles will help the organization move forward for success. (Lila, 2012)

In fact, Lila's focus on educated employees is somehow correct, as they are the ones who can understand better these principles and who can initiate change. However, in today's environment, this should not be the rule since change needs to be communicated to all personnel involved even to the least educated ones because they are the ones performing the daily activities and they are the basic change agents. If they don't know what is happening around them, they will not be able to implement the change the way it should be.

Yogesh, ChandraMohan and Arrakal (2012) proved in their case study that an Electrical manufacturing industry in India based their lean application on continuous improvement, preventive maintenance and good senior management strategy. (Yogesh, ChandraMohan, & Arrakal, 2012)

Nordin, MD Deros and Abd Wahab (2010) found out that most of the Malaysian Automotive industries are in the transition phase of implementing the lean manufacturing practice. They are facing two main barriers, which are the lack of understanding of the lean principles and the attitudes of the employees in the firm. (Nordin, Md Deros, & Abd Wahab, A Survey on Lean Manufacturing - Implementation in Malysian Automative Industry, 2010)

2.6. Lebanese industrial sector

The Lebanese industrial sector contains around 3,123 industrial companies based on February 2012 statistics. This number has declined during the last years, as it was 3,673 companies back in 2005 as per the Lebanese companies export guide edited by the Lebanese Industrial Association. (Conseil et Développement s.a.l., 2012)

These companies are divided in the different Lebanese regions as follows:

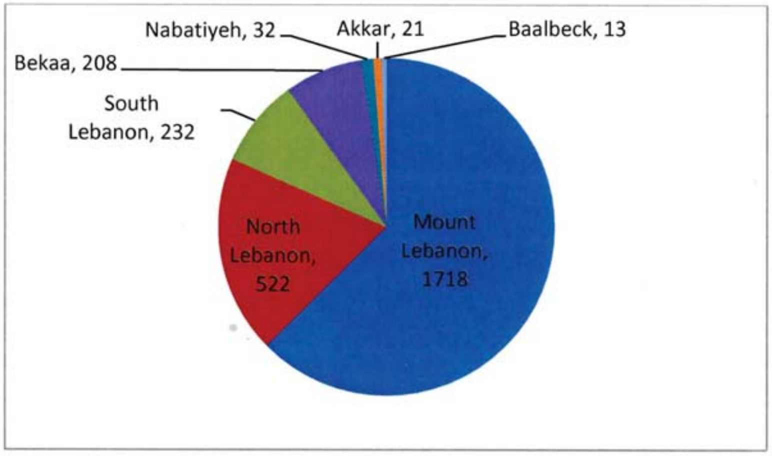


Figure 7: Repartition of Lebanese Industries per region

(Conseil et Développement s.a.l., 2012)

Furthermore, different types of activities are performed inside the Lebanese industrial sector generating a variety of products that are delivered to the customer in order to satisfy the Lebanese market demand and to export these goods to other countries. These activities are divided as per the following table.

Table 1: Repartition of Lebanese Industries per type of activity

(Conseil et Développement s.a.l., 2012)

Type of Activity	Number of companies
Agro-industry and Food Industry	556
Hardware and Ironmongery	411
ORE (metals)	386
Furniture	351
Carton	345
Tissues and Clothing	299
Chemicals	259
Electric Equipment	202
Wood	178
Jewelry	94
Shoes	82
Miscellaneous	54

Based on the Lebanese industries available, Lebanon imports and exports goods and services to and from different countries around the globe keeping a dynamic economical sector.

Exports are calculated as $5.113 billion and imports as $15.78 billion in 2010. (Lebanon Trade, Lebanon Exports, Lebanon Imports, 2010)

Lebanon mainly exports jewelry, chemicals, fruits and vegetables, tobacco, electrical power machinery, paper, textile fibers and other miscellaneous goods.

Lebanon's main export partners are as per the following diagram:

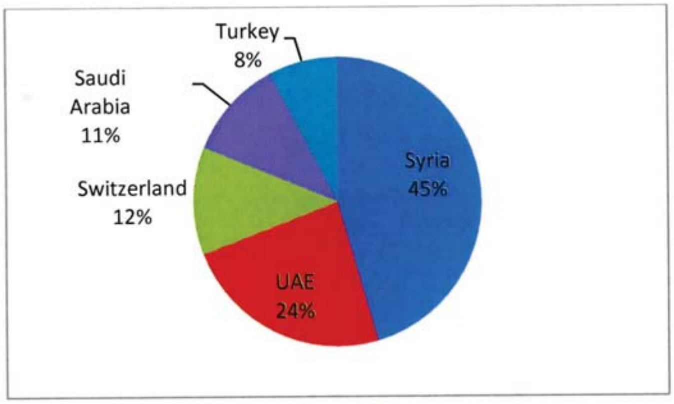


Figure 8: Lebanon's main export partners

(Lebanon Trade, Lebanon Exports, Lebanon Imports, 2010)

According to the Lebanese Ministry of Industry, Lebanon's industrial exports were $2,688 billion from January to November 2012, dropping from $3,044 million in 2011 and from $2,920 million in 2010 as per Figure 9. (Soueid, Ghanem, Hariri, & Sayess, 2013)

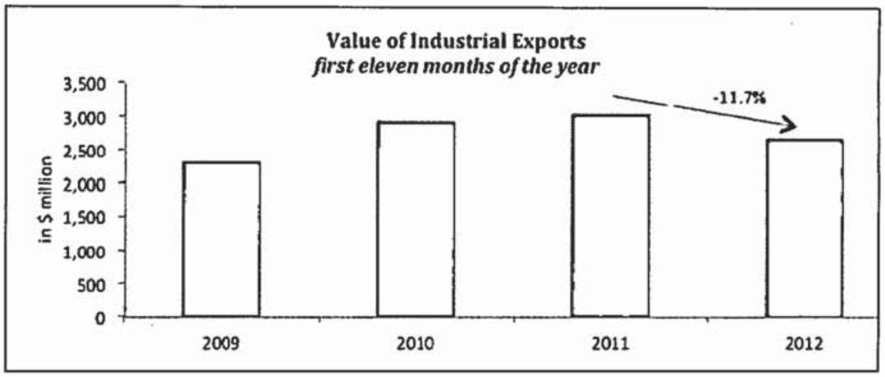


Figure 9: Indutsrial exports 2009-2012

(Soueid, Ghanem, Hariri, & Sayess, 2013)

Below are the most important industrial export sectors in Lebanon in terms of market share:

Table 2: The most important industrial export sectors in Lebanon

(Soueid, Ghanem, Hariri, & Sayess, 2013)

Industrial Sector	Shares in In million $	Percentage of the market share
Machinery and mechanical appliances	434	16.2%
Base metal articles	421.8	15.7%
Pearls and stones	378.2	14.1%

As for imports, they concentrate around cars, medical products, paper, textile fabrics, tobacco, chemicals, clothing and other imported goods. Lebanon's main import partners are as per the following diagram:

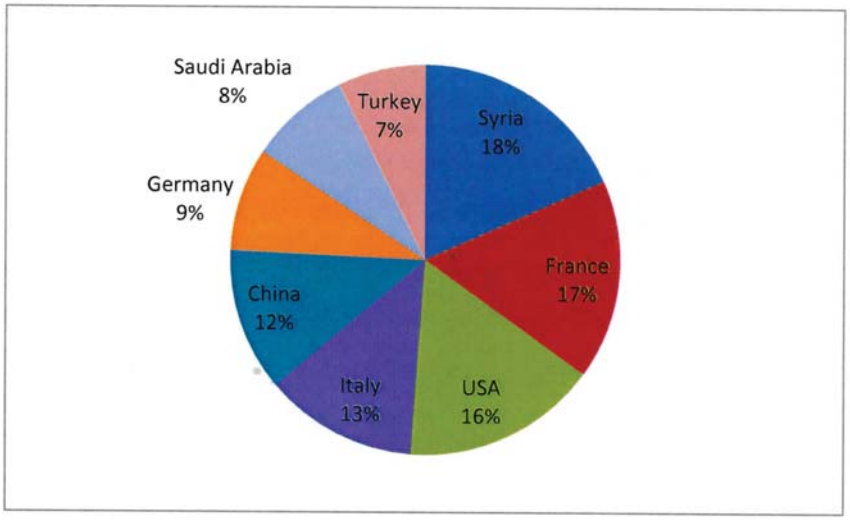


Figure 10: Lebanon's main import partners

(Lebanon Trade, Lebanon Exports, Lebanon Imports, 2010)

Lebanon has signed over 30 bilateral trade and economic agreements with European and Arab countries. All these agreements require cooperation between the nations and this in over 120 sectors such as tourism, culture, post, telecommunications and transport.

Lebanon is not a member of any customs union but has signed bilateral free-trade area agreements with Iraq, Egypt, Kuwait, Syria, Jordan and the United Arab Emirates.

At the regional level, Lebanon has signed the "Taysir" agreement, which foresees the establishment of the Greater Arab Free Trade Area (GAFTA) grouping 17 Arab countries. Lebanon also signed in 2002 an Association Agreement with the EU, which includes the progressive abolition of tariffs on imported European manufactured goods.

Lebanon is among the most open countries in the MENA region. (Dessus & Ghaleb, 2006)

Despite all the agreements that Lebanon has signed, domestic competition is limited in Lebanon and this due to two legislative elements:

- No competition law in Lebanon.
- The exclusivity to supply various international trademarks on the Lebanese market.

The size of the Lebanese pharmaceutical market is estimated at approximately $300 million. Traders market constitute around 2,737 different types of drugs while manufacturers have 747 types of drugs.

The total number of medication types available in the Lebanese market is around 3,484 based on a research done in 2000. (STATUS OF THE PHARMACEUTICAL INDUSTRY IN LEBANON, 2003)

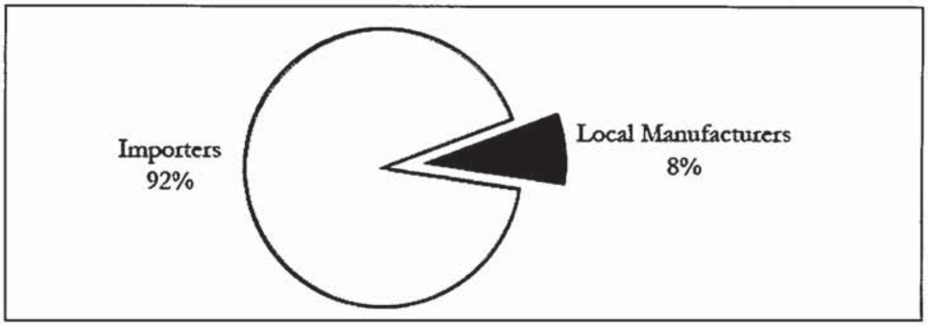


Figure 11: Distribution of market shares

(STATUS OF THE PHARMACEUTICAL INDUSTRY IN LEBANON, 2003)

Pharmaceutical products trade balance is largely in deficit. Imports are more than 65 folds that of exports. The average annual growth of pharmaceutical imports is around 9 percent.

Pharmaceutical products are mainly imported from France, United Kingdom, Germany and Switzerland. In 1999, more than 18 percent of all pharmaceutical imports originated from France and 17 percent from the United Kingdom. Less than 2 percent came from Arab countries such as Syria, Jordan, Saudi Arabia, United Arab Emirates, Egypt, and Kuwait. (STATUS OF THE PHARMACEUTICAL INDUSTRY IN LEBANON, 2003)

Lebanese pharmaceutical exports are mainly destined to Arab countries.

In 1999, more than 33% of all pharmaceutical exports were destined to Jordan and around 16%to Iraq, 10% to the United Kingdom and others to Syria, Jordan, Kuwait, Bahrain, Oman, United Arab Emirates, United Kingdom, and Cyprus.

A Lebanese pharmaceutical industry, "Algorithm", is trying to implement lean in order to increase the productivity and to contribute to the growth of the Lebanese industrial sector.

2.7. Lean and cGMP environment

(O'Rourke & Greene, 2006)

Pharmaceutical industries, especially "Algorithm Pharmaceutical manufacturers", work in a cGMP environment in order to deliver the best quality of products for the customer and this through a whole production and testing process.

The current good manufacturing practices (cGMP) are regulations set by the US food and drugs administration. GMP tends to provide a consistency in the operations and a control of the quality in order to meet the standards. (Chowdary & Damian, 2012)

According to the US FDA, adhering to GMP requirements assures the quality, purity and the strength of the medication that is produced. In addition, it prevents risks of cross-contamination, deviations, mix-ups or any error that can occur in the production cycle. FDA mentions that these requirements are flexible and need to be updated on a regular basis, from which comes the name "current" before the GMP name.

During the production cycle, testing is required at each stage and this in small quantities in order to guarantee the quality and to detect the errors before they are moved to the next stage and delivered to the patient. (FDA, 2009)

GMP covers all aspects of the production since the reciept of the raw materials from the supplier to the final delivery of the products to customers going through all the phases of manufacturing, packaging, controlling and testing.

cGMP is based on 10 principles:

2.7.1. Writing step by step operating procedures and instructions (SOP).

2.7.2. Following written procedures and instructions.

2.7.3. Documenting the work.

2.7.4. Validating the work – Prove that the system does what it is supposed to do.

2.7.5. Design and construction of facilities and equipment.

2.7.6. Maintaining facilities and equipment.

2.7.7. Defining, developing and demonstrating job competence.

2.7.8. Protecting product against contamination (cleanliness / hygiene).

2.7.9. Controlling components and Product related processes – Focus on Production.

2.7.10. Planned and periodic audits.

As per the table below, the cGMP and lean manufacturing both tend to improve the productivity of the firm but the perspective differs between these two strategies.

One of the basics of cGMP is the existence of a big number of documentations, qualifications and audits. Each procedure and operation requires a certain documentation to follow and to report for better achievement of the control. It doesn't tend to reduce the product cycle time but focuses more on the quality rather than on balancing quality with productivity as lean does.

The following table shows the difference between lean and cGMP principles required.

Table 3: Comparison of lean and GMP manufacturing

(O'Rourke & Greene, 2006)

A comparison of lean and GMP manufacturing. Area	cGMP	Lean manufacturing
Objectives	· Ensure product effectiveness · Prevent harm	· Reduce waste · Create value
Focus	· Product development, manufacturing and quality assurance	· Value stream
Approach to manufacturing	· Quality first	· Quality balanced with productivity
Improvement	· Regulated and prudent	· Continuous and simultaneous
Typical goals	· Follow validated process · Prevent deviation	· Reduce cost · Improve quality · Decrease cycle time · Reduce inventory · Improve delivery
Typical tools	· Documentation · Personnel qualifications and training · Cleanliness · Validation and qualification · Complaint review · Audits	· Value stream mapping · Kaizen improvement · Error proofing · Moving to pull · Simple flow · Training · Quality function deployment

2.8. Conclusion

In this Chapter, we went over the lean manufacturing strategy talking about its origin through history and elaborating the principles that need to be followed for a good lean manufacturing implementation. Then, we listed the lean wastes that should be avoided through the whole production process and this by applying the different lean tools and methods that we detailed in the chapter. From this, we learned that a company can encounter waste at different stages of the product life cycle and that one should try to eliminate them.

In addition, we learned that a company can reduce waste by tools that can be used separately or combined for a better achievement of the results and that these tools will help decrease the costs and increase the profitability of the company.

Furthermore, we saw how lean is implemented worldwide and this through researches done by different authors around the globe. This made us understand that some companies are applying lean in their strategies and some others are still in the transition phase of lean while others are still using the traditional way of production. We could also identify that lean concept can differ depending on the expertise and on the level of the employee inside the company where highly skilled and the more educated employees are more aware of the lean concepts and tools.

Then, we talked about the Lebanese industrial sector and we concluded from this part of the chapter that this sector occupies a good share in the Lebanese economy and that it is crucial to develop it for better growth of the country and for an increase in the Lebanese exports. This research was done in "Algorithm", a Lebanese industry that manufactures Lebanese medications for Lebanon and for the export markets. A better application of the lean concept in this company and an increase in the exports of "Algorithm" will contribute to the growth of the overall Lebanese exports.

This chapter made the topic clearer and we found that it was important to implement lean manufacturing in the company's strategy for a better profitability of the firm.

Then, we discussed the cGMP principles and compared it to lean in order to better understand the way the information is processed in "Algorithm".

In the following chapter, we will detail the methodology used with all related research questions and hypotheses. We will see how the survey was developed, how the sample was chosen and how the survey was conducted. In addition, we will state the dependent and independent variables that will be manipulated through the whole process trying to find the link and develop an efficient conceptual framework.

The results of the survey will be stated depending on the participants' answers.

Chapter 3

Procedures and Methodology

In the previous chapter, we described the lean manufacturing strategy with all the principles it targets stating its origin and relating how it evolved over time. Then, we listed the wastes that could encounter throughout the whole product life cycle and that lots of companies try to decrease and to eliminate as much as possible by using several tools that could help decrease costs and increase profitability while keeping a high standard of quality.

At a later stage, we analyzed some articles written by different authors around the world in order to better understand the implementation of lean in different companies worldwide. We also went through the Lebanese industrial sector and cGMP principles.

Now, It is time to introduce our problem, hypotheses, research questions, methodology, sample and variables.

The methodology will apply to "Algorithm pharmaceutical manufacturers", a Lebanese industry and this by developing a survey that will be distributed to employees from different levels of the organization going from the top managers to the employees passing through middle managers and supervisors.

3.1. Research problem

The wastes that are occurring inside the Lebanese industries are reducing the productivity leading to higher cost and to lower quality of the finished goods delivered to the clients. These wastes have a negative effect on the performance of these firms, their profitability and their output.

In addition, higher expenses are generated, more defects are obtained and the production cycle time is long leading to a delay in the delivery of the products.

Therefore, the cost may be too high comparing it to the effectiveness of the production.

Several problems will be addressed in this chapter in order to assess the implementation of lean principles inside "Algorithm" industry. Employees need to be aware of all these tools for a better achievement of the work and for a better productivity. In addition, these tools need to be applied in the daily tasks for a better productivity.

The aim of this study is to identify how lean is implemented in "Algorithm Pharmaceutical manufacturers", a cGMP environment, especially in its production cycle and try to find how it is evaluated on the diverse workers' levels in order to increase the company's productivity and profits while reducing costs and the excess of work-in-process (WIP) inventory.

Therefore, the problems that will be discussed will mainly cover the following issues:

- Wastes are occurring at different stages of the production cycle leading to less productivity.
- Lean tools application may not be perceived the right way by employees who may resist change.
- The wastes that need to be eliminated for a better productivity.
- Many barriers are preventing lean from being implemented the right way.

3.2. Research questions

The problems that were cited in the previous part of the chapter will be addressed throughout the thesis by answering the following research questions:

- RQ1: Do managers and team members inside "Algorithm Pharmaceutical Manufacturers" know about lean manufacturing principles?
- RQ2: Are lean tools applied inside the industry? How is this assessed from different levels of employees?
- RQ3: Do lean tools have a positive impact on the productivity of "Algorithm" Lebanese industry?

RQ1 and RQ2 will be answered with the hypothesis H1.

RQ3 will be answered with the hypothesis H2.

3.3.Hypotheses

For this, two general hypotheses will be tested trying to answer the research questions:

- H1: Lean manufacturing tools are seen as an efficient management tool more and more adopted/implemented in the production cycle.
- H2: Lean manufacturing tools will increase the productivity by reducing waste.

3.4.Research design and methods

The research is based on a survey that was developed in order to assess the implementation of lean tools inside "Algorithm Pharmaceutical manufacturers" and this by taking the input of employees from different departments and levels in the company.
The methodology used is qualitative. It will cover lean tools application, the main problems employees are facing in their daily tasks and the flow of information and materials.
Furthermore, this survey will try to target the employees' perception about lean manufacturing. It will try to identify how this strategy will help them in their daily tasks and in increasing the productivity of the company. (re. Appendix A)

The survey is divided into several sections; the introduction part helps us identify the level and expertise of the employee inside the company in order to be able to identify the assessment of lean from different perceptions. Then, come four sections divided as follows (re. Appendix A):

- Questions 1-19 contain general questions in order to test the lean manufacturing knowledge of the employees surveyed and their perception about this concept.
- Questions 20-49 are more specific and are related to the facility, operations, transactions that are practiced inside the plant during the different stages of the product life cycle.
- Questions 50-89 deal with the application of the lean manufacturing tools inside the company and how employees apply these methods in their daily tasks. In addition, they cover the management impact in adhering to the best practice and to the methods to be applied in order to increase profitability of the organization.

- Questions 90-107 evaluate the effect of lean manufacturing tools in the company's output.

From this survey, we will try to identify the degree to which lean tools are used and to examine their impact on the productivity, the profitability of the company and the quality of the product.

The questions were set up on five-point likert scale in order to measure the level to which employees agree with the actual application or not of lean tools and principles. The scale was ranged from 1 to 5 where 1 = Strongly Disagree, 2 = Disagree, 3 = Neither, 4 = Agree, 5 = Strongly Agree. The prime of the survey was to keep questions simple and short to be well understood by all levels of employees.

The survey will help identify the impact of factors such as changeover, operator involvement and skills (kaizen), equipment performance (total productive maintenance) and standardization of the work on the elimination of waste inside "Algorithm". These wastes vary from waiting time between different steps, product defects and transportation thus influencing the company's performance. (Ahrens, 2006) (Nordin, Md Deros, & Abd Wahab, 2010) (Viswanathan & Littlefield, 2009)

Cronbach's alpha will test the reliability of the survey in order to measure the internal consistency of the research that was performed. It is agreed that the acceptable lower limit is 0.7. However, a value as low as 0.6 can be accepted.

For better significant results, alpha should be higher than 0.8.

This will be calculated using "SPSS" analysis procedures (linear regression and Chi-Square). The analysis was performed separately on the employees / managers in order to compare the assessment of each of these tools on lean implementation.

Furthermore, two other techniques were used in order to test the results and to verify them from a personal point of view:

- A focus group performed on 8 team members from the production department. It took around 1 hour and notes were recorded progressively as soon as they were generated by the participants. This was interesting since everyone was proposing his ideas and they were all collected for analysis. (re. Appendix C)

- A depth-interview conducted with the production supervisor for around 30 minutes in order to understand his opinions in a more sensitive way than being surrounded by other employees. (RE. Appendix D)

3.5.Sample and data collection methods

The sample for this research is collected from employees working inside "Algorithm Pharmaceutical Manufacturers".

The company englobes 400 employees (N=400). Among them, 100 are involved in the operations and they were asked to fill the survey. Only 70 employees replied. It grouped employees from several departments involved in the production cycle from managers, to supervisors to team members and this to take into account all the factors that might affect production and that can lead to waste and to an increased cost.

These departments group mainly production department, materials control, Quality assurance, Quality control, technical services, product development, maintenance department and managers from administrative positions.

The level of education of these employees ranged from people with primary school education to highly educated employees holding master degrees.

In addition, the year of experience inside "Algorithm" also ranged from 0-3 years to more than 20 years, which gave us a wide variety of education and expertise. This will help us know the difference of assessment of lean perceived from different levels of employees.

The survey was individually distributed to employees in hard copies and they were asked to fill out the survey after explaining to them the purpose of such a questionnaire. Reminders were sent to team leaders each two days and this by phone in order to make sure surveys are being filled. They were all asked to answer the questions "honestly" in order to get the real picture of lean implementation inside "Algorithm".

Questionnaires were sent back after two weeks and were introduced to "SPSS-IBM" statistical for validity and reliability testing and for correlations. The other employees, mainly from QC department didn't send back the survey as they said that they don't have any idea about the lean concept.

The sample was divided as follows:

Table 4: Sample repartition

Position	Number	Merging categories
Managers/supervisors (Production)	7	14
Managers/supervisors (QA)	2	
Managers/supervisors (maintenance)	1	
Managers/supervisors (administrative)	3	
Managers/supervisors (QC)	1	
Team members	56	56
Total (sample size)	**70**	

At first, managers and supervisors were asked to fill out their position but at a later stage, they were all merged together for a better consistency of the results.

3.6. Variables and Conceptual framework

In order to test the implementation of lean manufacturing tools, and to try to verify the hypotheses that were developed, questions were divided into three categories for a later analysis.

At first, questions 1, 2, 3, 4, 5, 9 and 17 were used to test how well employees and managers know about the lean manufacturing tools in general.

Then, the rest of the questions were divided into 6 different variables. The independent variables that will be tested are related to the different lean manufacturing tools that were developed in the previous chapter (Kaizen, Total productive maintenance, Just-in-time and standardization). They will be correlated to one dependent variable, which is the effectiveness of such implementation on the company's productivity.

The questions will be divided as mentioned in Appendix B.

For that, the independent variables will be first tested separately in order to see to which extent managers and team members think that lean manufacturing tools are being applied inside "Algorithm" production in their daily tasks.
This analysis will be used to test hypothesis H1.
Then, a framework will be developed in order to understand the effect of such tools on the productivity of the company. It will be a model to test hypothesis H2.

The following model is defined for studying the assessment of lean implementation inside "Algorithm pharmaceutical manufacturers". We will try to study the effect of lean tools on the effectiveness of the production in the industry. This model and these relationships will be tested using "SPSS".

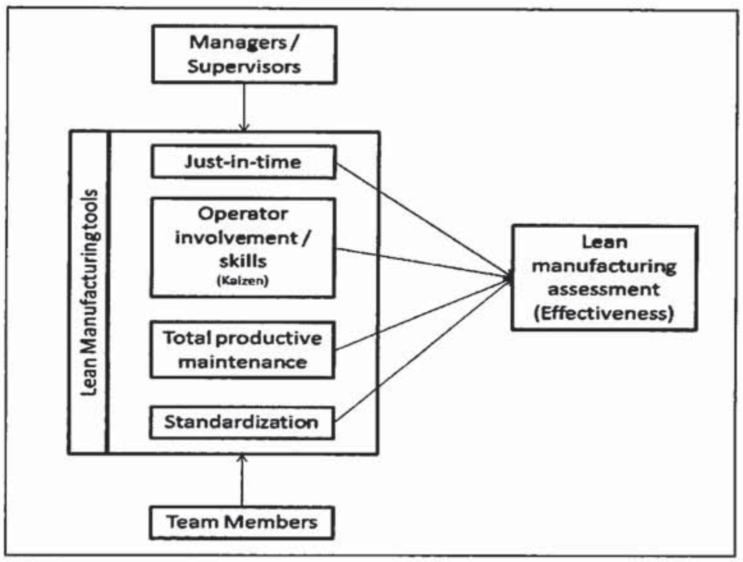


Figure 12: Conceptual framework

This chapter stated all research problems, research questions, hypotheses that will be tested at a later stage of our thesis in order to better understand the implementation of lean manufacturing inside the company. It stated the tools used in our methodology, which is a survey, performed inside "Algorithm" company with the sample chosen, a focus group and a depth-interview.

In addition, this chapter proposed the variables to be tested and the framework to analyze.

In the following chapter, we will discuss and analyze the results of the survey and try to prove if our hypotheses are valid or not.

Chapter 4

Findings

In the previous chapter, we went through all the methodology process that we worked on in the thesis, stating the research problem and the research questions that we will try to answer based on the results we will obtain from the survey. In addition, we stated two hypotheses that we will test in this chapter in order to know if they are significant and whether they are applicable or not.

Furthermore, we talked about the research design and the methods used during the survey and a briefing of the methods that will be used during our analysis. Then, we introduced the sample and the different independent variables and the dependent variable that will be tested to prove our hypothesis and we concluded the chapter by developing a conceptual framework that will be the base of our research and of our tests performed.

In this chapter, we will analyze the results of the survey that was performed trying to prove or not our hypotheses and trying to understand to which extent lean manufacturing tools are being applied inside "Algorithm" company and this from managers' and team members' opinion.

4.1.Analyze of results

In the statistical analysis of hypotheses H1, participants were divided into two groups (Managers/supervisors and Team members) in order to see how these tools and principles are perceived from the different points of view.

Note that in all histograms and tables, group 1 is assigned to the managers / supervisors and group 2 to team members.

The following table and histogram represent the mean of the answers obtained from the questions related to the knowledge of lean manufacturing among employees.

Table 5: Mean of the lean knowledge

	Managers	Team Members
Mean	3.55	4.03
Meaning	Positive	Positive

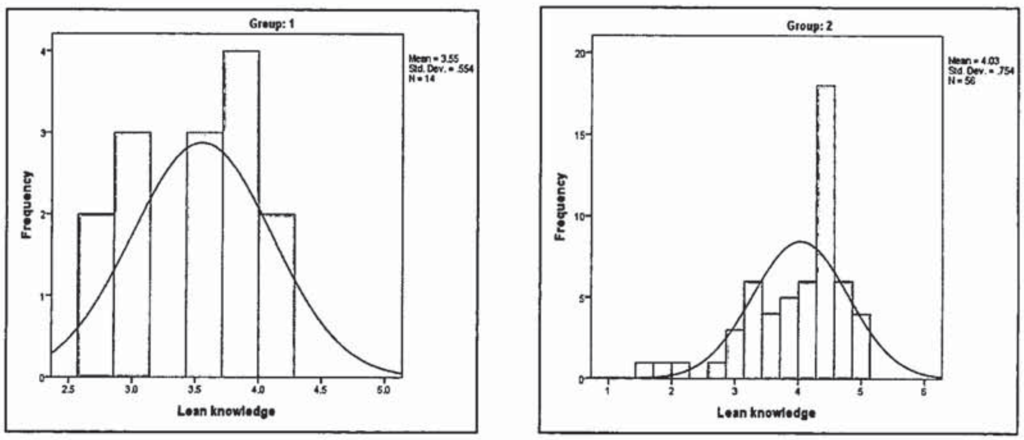


Figure 13: Lean Knowledge Histogram

Based on the table above, we can see that employees, in general, have knowledge about the lean manufacturing principles. Team members think that they know the tools and believe that the company is moving towards lean implementation a bit more than the management. Managers are somehow more realistic and think they need to know much more about these principles for a better improvement.

The following table and histogram represent the mean of the answers obtained from the questions related to the kaizen variable as per appendix B.

Table 6: Mean of Kaizen

	Managers	Team Members
Mean	3.23	3.00
Meaning	Neutral	Neutral

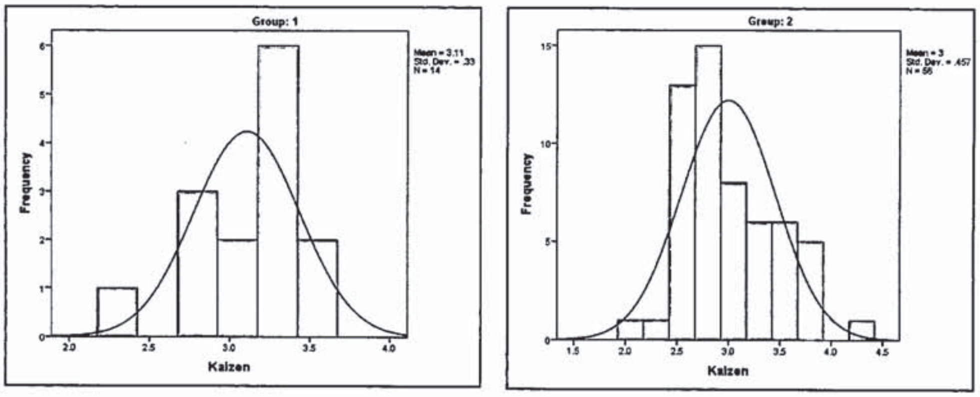


Figure 14: Kaizen Histogram

Based on the above table, we can see that managers believe that employees are empowered and involved in decision making more than team members think. This is linked to a normal fact that employees generally don't feel that they are appraised in an appropriate way and don't feel that managers make them involved in decision making or in giving their opinion when need be.

In addition, team members usually tend to be less satisfied in their work than managers are.

In general, the average is not high which links us to the fact that Kaizen is not well implemented and employees are not enough involved.

The following table and histogram represent the mean of the answers obtained from the questions related to the standardization variable as per appendix B.

Table 7: Mean of standardization

	Managers	Team Members
Mean	3.48	4.19
Meaning	Neutral	Positive

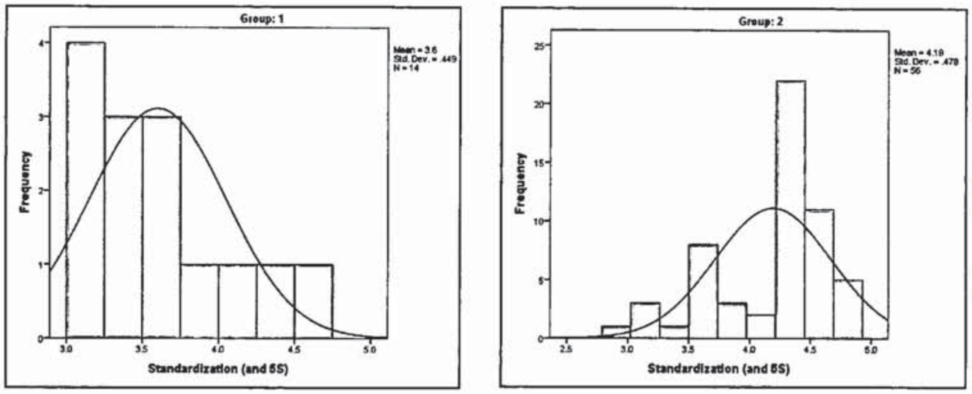


Figure 15: Standardization Histogram

Based on the table above, the company adopts the standardization tool as mean variables are relatively high. This is linked to a big number of standard operation procedure (SOP) that each department in the company develops especially the production department where each procedure, each equipment from the simplest to the most sophisticated one needs to be detailed in an SOP that team members and managers have to follow in their daily tasks.

The mean is relatively lower from the managers' side because managers think that team members can violate the application of some "SOPs" and do the work in another way. However, in general, standardization is applicable.

This variable is also related to the application of the 5S tool. People may not know what the tool is about but sorting, shining, setting in order, standardizing and sustaining is one of the major characteristics and the requirements of a cGMP pharmaceutical environment in order to guarantee the quality of the product manufactured and the best practices of cGMP procedures.

The following table and histogram represent the mean of the answers obtained from the questions related to the just-in-time variable as per appendix B.

Table 8: Mean of JIT

	Managers	Team Members
Mean	2.77	2.86
Meaning	Neutral	Neutral

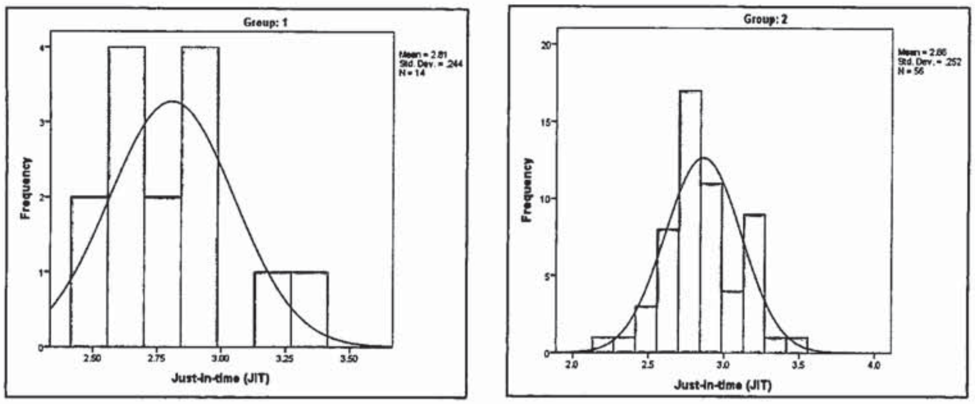


Figure 16: Just-in-time histogram

Based on the table above, both managers and team members think that work is not always performed in the time needed. So many processes are delaying the work and so many documentations, approvals, deviations, non-value added activities are in the production phase. This is causing the process to be longer and the work to be performed in a more complicated way.

There's no significant difference between managers' and team members' opinion concerning the JIT variable as they both see the non-application of JIT and the delays of the process by lots of procedures.

The following table and histogram represent the mean of the answers obtained from the questions related to the total productive maintenance variable as per appendix B.

Table 9: Mean of TPM

	Managers	Team Members
Mean	3.13	3.78
Meaning	Neutral	Positive

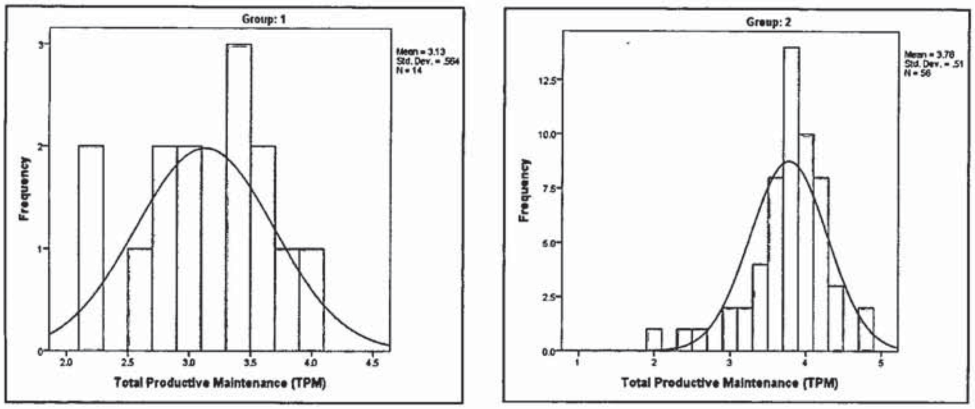


Figure 17: TPM histogram

Based on the table above, maintenance department is somehow performing the tasks but this needs further improvement depending on the managers' and team members' opinion. The mean of the team members is a little higher than the managers' as managers are more demanding and always seek for more perfection than team members do. Usually team members can be satisfied with just what they have and don't ask for more if everything goes right.

The following table and histogram represent the mean of the answers obtained from the questions related to the effectiveness of lean manufacturing on productivity as per appendix B.

Table 10: Mean of effectiveness

	Managers	**Team Members**
Mean	3.20	3.52
Meaning	Neutral	Positive

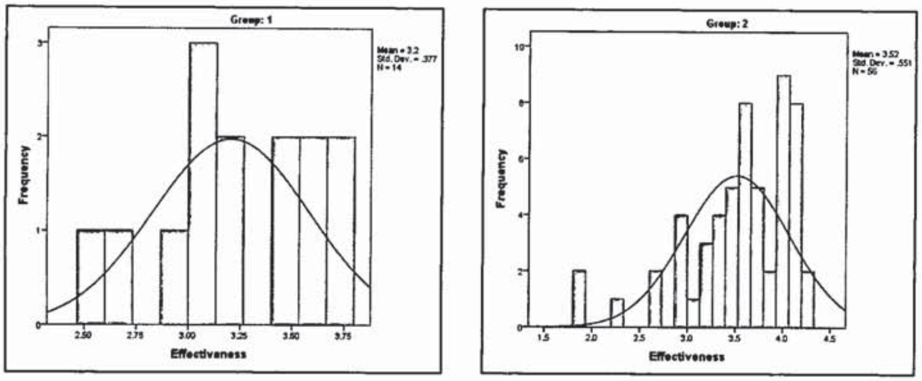


Figure 18: Effectiveness histogram

Based on the table above, employees in general think that lean manufacturing contributed in a certain way to the effectiveness of the company more precisely the production department. This effectiveness is not so high since many factors are contributing in lowering the productivity. This will be discussed at a later stage while analyzing the framework model.

In order to prove or not the hypothesis H1, let us review all the variables that were just detailed and assessed by the different levels of employees inside "Algorithm Pharmaceutical Manufacturers".

- Lean knowledge: Employees know about the lean manufacturing tools in general but are seeking to learn more as they think that they don't master all the tools needed. Team members are just satisfied with what they are trained on.
- Kaizen: Managers think more than team members do that employees are empowered. Team members are not so satisfied with their work and don't think they are well appraised.
- TPM: Total productive maintenance is performed but managers think this should be more reinforced and developed.
- Standardization: work is considered to be standardized and this from managers' and team members' opinions.
- JIT: this tool is not well implemented in the company's strategy as lots of information need to be detailed, many operations need to be performed in addition to reviews, multiple approvals and activities that may delay the process

eventhough the distribution of the plant is well organized in order to facilitate the work.

- Effectiveness: all employees feel that production is achieving effectiveness but not in the best output possible.

In conclusion, we can see that hypothesis H1 is partially verified taking into account the mean that were calculated from all lean tools determinations with values of 3.16 for managers and 3.46 for team members and this from the mean of the independent variables that are kaizen, standardization, total productive maintenance and just-in-time. The mean is higher than "3" so we can verify the partial application of hypothesis H1. Working on the lean manufacturing tools needs to be improved inside the company.

In order to test the reliability of our variables and before proceeding with the model testing, a scale analysis on all variables was performed using "SPSS". It turned out that all variables are reliable as per the table below with a cronbach's alpha of 0.820 in the managers' group and 0.787 in the team members' group.
So, our overall research is considered consistent and taking into consideration different statistical assumptions.

Table 11: All variables reliability testing

Reliability Statistics

Group	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
1	.820	.850	6
2	.787	.792	6

After introducing our variables and our framework in the previous chapter, now it's time to demonstrate the relation existing between them and to see the significance in order to prove or not the hypothesis H2 that was previously mentioned.

In order to demonstrate the hypothesis H2, a testing of the framework that was illustrated in chapter 3 needs to be performed.

As discussed in the previous chapter, the variables will be divided as follows:

Table 12: Framework variables

Independent variable	Dependent variable
Kaizen	Effectiveness of lean on productivity
Just-in-time (JIT)	
Total Productive maintenance (TPM)	
Standardization	

The first test that will be used in "SPSS" will be the multiple linear regression analysis based on two different repartitions of the sample chosen:

- Position: Managers or team members
- Years of expertise: 0-3 years, 4-7 years, 8-15 years, 16-19 years or more than 20 years.

Following that, we will do a Chi-Square test in order to validate better our hypothesis H2.

The technique, which is the multiple linear regression, was used choosing kaizen, Just-in-time, total productive maintenance and standardization as independent variables and trying to find the correlation between them and the dependent variable which is lean effectiveness on productivity.

After introducing all these variables in "SPSS" and commanding all the parameters needed, the below results were obtained. The complete tables generated by "SPSS" are attached in Appendix E.

Table 13: Reliability and ANOVA of the linear regression (by position)

Parameter	Group (1: Managers / Supervisors 2: Team Members)	Value	Interpretation
Reliability (R Square)	1	0.595	Some reliability
	2	0.529	Some reliability
Anova	1	0.063	Significant difference
	2	0.000	Significant difference

This models show a consistency of 0.595 for the managers and 0.529 for the team members which is relatively low but shows some reliability as this is a social science.

The table above also shows the analysis of variances (ANOVA) established, which is the difference between the mean of the two groups (managers and team members). As "Sig." is less than 0.05 in the two groups, we can consider that the difference between them is significant.

Then, the table below shows to which extent our hypothesis H2 is considered significant or not. We can see that all values of the variables in the managers group are higher than 0.05 so our hypothesis is rejected in the managers' group, assuming a confidence level of 95%.

As for the team members' group, the significance is higher than 0.05 for the Kaizen and Just-in-time variables but lower than 0.05 for the TPM and standardization variables.

So, we can conclude that managers don't think that these lean manufacturing tools have a direct impact on the productivity of the company whereas team members think that TPM and standardized work have a direct impact on the productivity.

H2 is rejected for managers and half-rejected for team members considering the difference in the tools impact.

Table 14 : Correlation of the linear regression (by position)

Group	Variable	Result	Interpretation
1	Kaizen	.212	Non-significant
	Just-in-time (JIT)	.542	Non-significant
	Total Productive Maintenance (TPM)	.449	Non-significant
	Standardization (and 5S)	.653	Non-significant
2	Kaizen	.309	Non-significant
	Just-in-time (JIT)	.210	Non-significant
	Total Productive Maintenance (TPM)	.006	Significant
	Standardization (and 5S)	.000	Significant

If we look more in details at the table 21 in Appendix E, we can conclude the following equations:

Managers / Supervisors: $Y=0.202+0.457X_1+0.395X_2+0.137X_3+0.126X_4$

Team members: $Y=0.202+0.457X_1+0.395X_2+0.137X_3+0.126X_4$

In these equations, X_1 is related to kaizen variable, X_2 to Just-in-time, X_3 to TPM and X_4 to standardization.

If we look at the column "Beta", we can see that all these factors have a significant impact on the study with values varying from 0.139 to 0.459.

A further test was performed with the linear regression and this by changing the division of the participants to their years of expertise inside the company. This range was divided as follows: 0-3 years, 4-7 years, 8-11 years, 16-19 years and more than 20 years of expertise.

The following model summary was obtained and the reliability from this reparation of the sample shows a higher consistency than the previous one where managers and team members were split into five groups. We note a higher reliability (0.946-0.998) in the groups ranging from 8 to more than 20 years. These employees are supposed to be the most experts in the field.

Table 15: Reliability of the linear regression (by expertise)

Model Summary

Expertise	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
						R Square Change	F Change	df1	df2	Sig. F Change
0-3 years	1	.794	.630	.556	.420	.630	8.510	4	20	.000
4-7 years	1	.698	.487	.385	.320	.487	4.751	4	20	.007
8-11 years	1	.986	.972	.916	.243	.972	17.351	4	2	.055
16-19 years	1	.99[c]	.998	.990	.026	.998	129.884	4	1	.066
>20 years	1	.973	.946	.732	.201	.946	4.411	4	1	.341

Based on the reliability that was proved in the previous table, a linear regression was performed but this time on a different repartition than the one previously done. The hypothesis was rejected for most of the cases except for:

- Total production maintenance variable in the 0-3 years' group (sig=0.003).
- Standardization variable in the 4-7 years' group (0.002).

Table 16: Correlation of the linear regression (by expertise)

Group	Variable	Result	Interpretation
0-3 years	Kaizen	0.272	Non-significant
	Just-in-time (JIT)	0.693	Non-significant
	Total Productive Maintenance (TPM)	0.003	Non-significant
	Standardization (and 5S)	0.101	Significant

4-7 years	Kaizen	0.893	Non-significant
	Just-in-time (JIT)	0.533	Significant
	Total Productive Maintenance (TPM)	0.755	Non-significant
	Standardization (and 5S)	0.002	Non-significant
8-11 years	Kaizen	0.412	Non-significant
	Just-in-time (JIT)	0.233	Non-significant
	Total Productive Maintenance (TPM)	0.631	Non-significant
	Standardization (and 5S)	0.813	Non-significant
16-19 years	Kaizen	0.705	Non-significant
	Just-in-time (JIT)	0.059	Non-significant
	Total Productive Maintenance (TPM)	0.530	Non-significant
	Standardization (and 5S)	0.201	Non-significant
➢ 20 years	Kaizen	0.973	Non-significant
	Just-in-time (JIT)	0.337	Non-significant
	Total Productive Maintenance (TPM)	0.823	Non-significant
	Standardization (and 5S)	0.792	Non-significant

The results that were obtained from the two tests that were used were not significant concerning the validation of our hypothesis H2 in the managers' group and in most of the categories of the second test.

Only TPM and standardization can be linked with the first test. Therefore, these variables can have a positive impact on productivity.

If we look more in details at the table 23 in Appendix E, we can conclude the following equations:

0-3 years: $Y=0.219+0.201X_1+0.326X_2-0.272X_3+0.584X_4$

4-7 years: $Y=1.527-0.218X_1+0.705X_2-0.030X_3-0.054X_4$

8-11 years: $Y=-8.304+5.5X_1+0.241X_2-1.866X_3+0.299X_4$

16-19 years: $Y=0.557+0.742X_1+0.155X_2-0.033X_3+0.032X_4$

>20 years: $Y=-0.507+1.301X_1+0.096X_2-0.014X_3-0.083X_4$

If we look at the column "Beta", we can see that all these factors have a significant impact on the study with values varying from 0.019 to 1.442. Therefore, the Just-in-time variable has a large impact according to the 8-11 years expertise group.

Furthermore, an additional test was performed on these variables in order to try to demonstrate H2. This test is the Pearson Chi-square.

The analysis showed the following results as per the table below:

- The significant results were for the Team members' group in all the variables treated: JIT, Standardization, Kaizen, TPM
- The non-significant results were for the Managers' group in all the variables treated: JIT, Standardization, Kaizen, TPM

Table 17: Chi-Square test

Variable	Group	Value	Interpretation
JIT	1	0.282	Non-significant
	2	0.011	Significant
Standardization	1	0.109	Non-significant
	2	0.000	Significant

Kaizen	1	0.282	Non-significant
	2	0.034	Significant
TPM	1	0.479	Non-significant
	2	0.026	Significant

The table shows the significance of the relationship between the variables in the team members' group with values less than 0.05 whereas these values are higher than 0.05 for all variables in the managers' group, assuming a confidence level of 95%.

So, the hypothesis H2 can be verified in the team members' opinion and not in the managers'.

This, in fact, can be linked to lots of factors that affect the productivity especially in a cGMP environment.

The results of the Chi-square test can be linked to the linear regression where H2 was also rejected in the managers' opinion for all variables whereas it was accepted in the team members' opinion in the TPM and standardization variables.

The Chi-square test could verify two more variables (JIT and kaizen) in the team members' group.

4.2.Discussions

Based on the results obtained in the previous part of chapter 4, we will see in this chapter the significance of our two hypotheses H1 and H2.

For H1, which is related to the implementation of lean manufacturing, we can see that the overall mean of lean tools is on the average scale varying from 3.16 for managers to 3.46 for team members.

So lean manufacturing strategy is implemented in some cases in the production cycle and the hypothesis H1 is partially verified and needs improvement.

- Kaizen (employee involvement) is on the average mean. Employees don't think managers allow them to take decisions by themselves and sometimes only managers have access to some information and are allowed to decide the faith of a product or a procedure.

- Standardization is implemented in a positive mean according to both team members and managers. If we link this variable to cGMP where much documentation is needed, we can demonstrate why this average is high in a cGMP pharmaceutical industry. This helps us prove our discussion of cGMP focus, in "Algorithm", on standardized procedures.
- JIT's (Just-in-time) mean is low. Going back to the previous point and to cGMP requirements, we can explain in a very simple way why this variable has a low mean. Many procedures are needed, lots of standard documentation have to be prepared and filled, lots of inspections, testing, audits and controls need to be performed. These are essential in a cGMP environment but they delay the work and prevent the production team from delivering the product on time as recommended by the customer.
- TPM (total productive maintenance) is performed but not in the exact way, as per employees' opinion. This is due to the fact that plant equipments are not the most recent available in the market and troubleshoot may happen during operation. As per the employees' opinion, TPM is not enough and should be reinforced for a better performance of the equipment and a decrease of the delay in the work process.

If we want to prove the partial application of lean tools in "Algorithm Pharmaceutical manufacturers", we will talk about the barriers that prevent such industry and the pharmaceutical ones to completely adhere to lean principles; they are linked to the application of cGMP requirements, in pharmaceutical industries, that consume a lot of time and this from documentations, standard operation procedures (SOP), deviations and other written procedures. If we compare the mean of each of the variable, we can see that the lowest is related to the just-in-time variable, which comes back to the same explication concerning the cGMP restrictions.

cGMP application doesn't go the same way as lean manufacturing eventhough both tend to provide the customer with the best product. As shown in the previous chapter, lean focuses on assuring a balance between productivity and quality while reducing waste, whereas cGMP focuses on quality based on documents, procedures and inspections.

Furthermore, cGMP focuses on batch production as it is the same in "Algorithm" but lean tends to manufacture one piece at a time in order to limit the production to the quantity needed by the customer. (Smart, 2010)

Smart (2010) also mentioned that cGMP requirements made the pharmaceutical industries shy in adopting lean principles. He is right since "Algorithm" wants to adopt the lean strategy and they are working so hard on implementing new procedures but some cGMP restrictions, especially the documentations, are preventing them from going totally lean.

He also mentioned, in another article, the need for such companies to go lean in order to reduce the different types of wastes they are encountering in their process and in order to increase efficiency. (Smart, Moving Toward Lean Manufacturing Implementation, 2010)

Chowardy and Damian (2012) mentioned that all the rules established by GMP and regulated by QA (Quality Assurance), namely the written documentations, are sometimes useless but their application is a must as any violation of the requirements can lead to penalties. They emphasis on the fact that all these procedures focus on quality and efficiency rather than on cost reduction.

He concluded in his articles that pharmaceutical industries are adopting the lean principles just because they heard from other companies that it helps reducing waste. (Chowdary & Damian, 2012)

In the table below, we can see again the difference between cGMP practices and lean manufacturing practices. The cGMP is more related to documents and reviews whereas lean tends to decrease cost, wastes, inventory and this by different tools that we elaborated in Chapter 2.

Table 18: Lean and cGMP

(Chowdary & Damian, 2012)

Area	cGMP	Lean manufacturing
Objectives	Product effectiveness Adequate confidence QA	Reduce/eliminate waste Create value Improve flow
Focus	Storage, process traceability, starting materials approval, and precise documentation	Product value stream Material flow Information flow
Approach to manufacturing	Quality is built into product throughout production	Quality along with productivity
Typical goals	Independence QC from production Follow validated processes Stage inspection GLPs	Reduce cost Improve quality Decrease CT Reduce inventory On-time delivery
Typical tools	Approved procedures Complaint reviews Quality audits	Value stream mapping 5S Kaizen Kanban CM QFD

Concerning the hypothesis H2, for the relationship existing between the independent variables which are the lean manufacturing tools and the dependent variable which is the effectiveness on productivity of lean implementation inside "Algorithm Pharmaceutical Manufacturers", we saw that the hypothesis could be verified in the team members' group and not in the managers' group and this with a significance lower than 0.05 for team members according to the Chi-square test. Linear regression showed a significance in two variables (total productive maintenance and standardization) in the team members' group.

An additional methodology was performed in order to verify the results obtained from the chi-square test and the linear regression for H2.

A focus group of 8 employees was established and they were asked the questions of Appendix C and this for about 1 hour. Based on their answers, we could understand better why the relationship exists between the tools of lean manufacturing and the productivity.

Furthermore, the depth-interview that was conducted with the Production Supervisor showed why in some cases, this relationship doesn't exist especially that "Algorithm" is working in a cGMP environment.

Team members think that the relation exists. Effectiveness is somehow met, on the average mean, as shown in the previous hypothesis H1, and they also think that lean tools are sometimes applicable.

According to their answers, team members think that they got some information needed concerning the lean manufacturing tools and principles and they are working hard in order to meet the target that the upper management set for them. They are trying as much as possible to limit the changeover time, to reduce the number of defects and to increase the productivity per line.

They were asked about the relationship between each of the tools and effectiveness on productivity and the resume of their answers is represented in the following points:

- JIT-Effectiveness: Effectiveness is not met because there are lots of documentation that are prepared and they consume a lot of time and prevent employees from doing work in the time frame requested from the management at the beginning of the schedule.
    - When a new machine is installed, lots of documents come and go and employees wait a long time just before they can start using the equipment.
    - Sometimes, when a problem occurs, they wait a longer time than needed in order to solve the problem and to get the final approval from several managers in order to proceed.
    - Different steps need multiple approvals and this also delays the production cycle.
    - Some non-value added activities, as per team members' opinion, are in place: too many papers filling, recording the data, waiting for formula update, waiting for release of ingredients…
    - Other than that, the work is considered well scheduled and monitored from all sides.
    - Changeover is getting faster with time.
    - Defects and rework of products are reduced.

So in order for the work to be more effective, team members think that these delays should be omitted which links to the fact that there's surely a relationship between the timing of the process (JIT) and the effectiveness. If all these non-value added activities are deleted, work will be faster and more productive. So this relationship is valid as per hypothesis H2.

- Kaizen-Effectiveness: team members think that they are not evaluated in a good way. Eventhough incentives were just implemented with the strategy of management to give financial rewards in case the target is met, these incentives are not frequent. Team members think that this lack of appreciation and rewards push them to be less motivated and less committed to work thus generating less productivity. This relationship is established in the eyes of team members; more employee involvement and appreciation leads to better productivity and the opposite is also true. So this relationship is valid as per hypothesis H2.
- TPM-Effectiveness: team members evaluate some equipment as being old and not well developed. They think that Total productive maintenance is, sometimes, not done the right way it should. They also think that the relationship exists between TPM and effectiveness because they assume that when maintenance department does the work more frequently, this will be more effective and they believe that when it's done the right way, the performance of the equipment is better and troubleshoots are less likely to occur. So this relationship is valid as per hypothesis H2.
- Standardization-Effectiveness: team members insisted on the fact that every operation they perform needs to be well described in a written document called SOP (Standard Operation Procedure) in order for them to better understand the process in each step of the production. They believe that a clear SOP will facilitate the work and increase productivity and this by reducing the number of defects.

  There's also a link with the sorting, shining and cleaning operations in the industry where each equipment is in its place and where all rooms are always clean and any waste and dirt are eliminated on a regular basis by the housekeeping team. This will make the work more organized and the flow simpler. So this relationship is valid as per hypothesis H2.

This leaves us with one conclusion which is the existence of a relationship between the tools variables and the effectiveness variable; H2 is more validated in the team members' group.

Furthermore, a depth-interview was conducted with the production supervisor to answer the questions of Appendix D and this in order to understand their perception of the relationship between the lean tools and the effectiveness of this strategy. This interview took about 30 minutes.

Based on his answers, we will try to find a link with the results of the chi-square test and the linear regression that gave values higher than 0.05 and which is translated by the fact that there's no relationship between the tools and the productivity as per managers' opinion.

The following points are related to his answers:

- JIT-Effectiveness:
  - Lots of documentations are prepared and they are certainly delaying the production but this doesn't affect the overall productivity of the company. According to him, these steps are essential for the good functioning of the operations and without them work is not well performed.
  - cGMP regulates the usage of these documentations which are essential.
  - These delays are not considered to be a non-added value activity.
  - The productivity is not affacted by these documenations and all the steps peformed need to stay as is because each step is done based on history and it needs to be well monitored for a better functioning. They are a must.

  So this relationship of hypothesis H2 is not valid.

- Kaizen-Effectiveness: production supervisor emphasizes on the fact that employees can't be empowered in all decisions. He surely believes that they can be involved in some issues but not in everything. According to him, some information can only be handled by managers and supervisors and not communicated to the employees. He believes that incentives are essential for employees' motivation but a full involvement in decision is not essential. It may also ruin the whole cycle if it's not controlled the right way and if the team members are not performant enough. So according to him, the productivity is not mainly based on the employees' empowerment.

So, this relationship of hypothesis H2 is not valid.

- TPM-Effectiveness: production supervisor assumes that there's a relationship existing between total productive maintenance and effectiveness but gives higher importance to the good manipulation of the equipment by the employees who need to take care of it.

  So, the relationship existing between these two variables is somehow valid but not in a direct link. In contrast, team members think that equipment performance is one of the major key for the reduction of the equipment troubleshoot and the production down-time.

  He stated that a TPM tool is being implemented which is the OEE (overall equipmement effectiveness). It is a tool in order to identify the equipment performance and is calculated trying to reduce the cycle time and increase the productivity.

$$OEE = \underbrace{B/A}_{\text{Availability}} \times \underbrace{D/C}_{\text{Efficiency}} \times \underbrace{F/E}_{\text{Quality}}$$

Figure 19: OEE formula

- Standardization-Effectiveness: based on the supervisor's answers, he stated that standard operation procedures are essential for the consistency of the work and the adequate communication of instructions to the team members but this should not be fixed. According to cGMP, these procedures, once standardized, need to be followed by letter and any deviation should go under a complete investigation which goes back to the point of JIT that we already discussed. These deviations will also involve several departments and several approvals. He agrees that sometimes, changes need to be done especially when dealing with products that may differ unless one needs to develop a single procedure for every different product.

Concerning the sorting, cleaning and shining, he agrees that everyone needs to adhere to these instructions to keep the environment clean and prevent any cross-contamination from occuring.

So the fact that the significance is higher than 0.05 (=0.109), which is not high comparing to other variables, can be just linked to the need of being more flexible concerning the application of some procedures.

This leaves us with one conclusion of the relationship between the tools variables and the effectiveness variable; H2 is validated in the team members' group and not in the managers' and supervisors' group.

This was both validated by the Chi-square test, the focus group that was done with the team members and the depth-interview that was done with the production supervisor.

4.3. Conclusion

In this chapter, we analyzed the answers that we obtained from the survey. They were essential in building an image of the implementation of lean manufacturing tools inside "Algorithm Pharmaceutical manufacturers" especially in its production cycle.

Furthermore, we established the relationship existing between the different independent variables that are the lean tools (Kaizen, Just-in-time, Total productive maintenance and Standardization) and the dependent variable which is the effectiveness of lean implementation that is directly linked to the productivity.

In order to discuss the results of the survey, we "SPSS" linear regression test and Chi-square test.

In addition, a focus group was performed with team members and a depth-interview with the production supervisor.

This analysis helped us to verify more or less the hypothesis H1 with all means around the average. As for hypothesis H2, it could be verified in the team members' group more than in the managers' group.

The research and the literature review showed that lean implementation is not as easy in a pharmaceutical industry as it is in any other industry. Lots of cGMP restrictions are standing in the way and employees are not always ready to accept the changes.

Based on the results obtained in this chapter, we can conclude the importance of such a study on different parts:

- As a company, "Algorithm" is certainly trying to improve its productivity by applying part of the lean principles in its strategy. Lean is partially implemented in the company. The research showed that it is somehow difficult to totally implement lean as there are lots of barriers that prevent such a change like cGMP and the culture of the employees especially the managers who are insisting on adhering to cGMP principles as if it is the only way for quality guarantee. Such an implementation needs lots of efforts from experts and lots of training of employees of different levels in order for them to understand the real importance of lean and its positive impact on the productivity.

  If the company goes lean, the wastes can be reduced as per the literature review and the productivity will increase.
- Concerning the Lebanese industrial sector, more precisely the pharmaceutical industry, we could find no reference on the total implementation of lean in Lebanon which can be linked to the unstable situation in the country which pushes every industry to keep the inventory big in order to stay secured in case anything happens.
- The Lebanese economy is depending on the growth of its industries. The more companies are producing, the more the economy is stable.
- Decision makers need to understand why lean is essential. They can't just accept the status quo. The world is evolving and so are the strategies. They need to adapt to new situations and go lean. By adopting lean, several benefits will take place as we saw in our literature review.
- Linear regression and chi-square tests per position showed better correlation of variables in the team members group. Therefore, managers are more resistant to change and they want to adhere more strictly to the cGMP regulations even if some wastes (waiting…) occur. So, they need to get trained more efficiently in order to be able to communicate the real information to their subordinates.
- Linear regression per year of expertise didn't show much correlation so the repartition per expertise is not so significant.

The following chapter will englobe our conclusion concerning the lean implementation and assessment in addition to some recommendations based on the findings.

Furthermore, we will state our limitations and the further researches that can be performed in the future for a better analysis of our hypothesis.

Chapter 5

Conclusions and Recommendations

After analyzing, in Chapter 4, the results obtained from the survey, the focus group and the depth-interview, we will conclude our thesis trying to find some recommendations for a better productivity of the firm.

The objective of this thesis was to study the implementation and assessment of lean manufacturing in a Lebanese industry, which is "Algorithm Pharmaceutical Manufacturers".

The results showed that lean tools are somehow applicable in the production cycle; standardization is among the tools the most used and Just-in-time is the tool that employees are not adopting very well due to lots of documentations and delays in the process.

Furthermore, the results showed a relationship between the application of these lean tools and the effectiveness and productivity of the company in the opinion of the team members whereas managers don't believe that this relationship is so tight. This is linked to the fact that cGMP requirements regulate all the process and they consume a lot of time. According to the managers, the cGMP requirements are the basic tools of quality and they are fundamental even if the work is delayed in some cases. Doing the job in a faster way without adhering to cGMP is not a guarantee for effectiveness and efficiency.

The challenge of a pharmaceutical industry, such as "Algorithm', is to try implementing lean tools in its strategy while following all cGMP rules and regulations in order not to get penalties. In fact, there should be a balance between lean and GMP for a better performance of the work because lean is essential for cost reduction and waste elimination and GMP is also essential in order to keep the best quality of medication especially that we are delivering the products to ill patients who are seeking to get healed.

Many employees may try to resist change and upper management may prefer the status quo finding themselves more secure but the world is evolving and lean is being implemented in lots of international companies where they are getting satisfactory results concerning the increase of the production size and the reduction of non-value added activities.

5.1. Recommendations

Finally, we can recommend some propositions for a better implementation of lean and for a better effectiveness and efficiency of the work:

- "Algorithm" should hire lean experts in the pharmaceutical industry in order to find the good balance between lean and GMP so that productivity is better and cGMP requirements are not violated. These experts will help all employees throughout the transition process in order to better understand the real advantages of lean and to accept the change that could give a positive impact on the production size.

  According to Greene and O'Rourke (2006), lean and GMP should be equal partners where new rules need to be more flexible in the GMP standards in order to meet lean. (Greene & O'Rourke, 2006)
- Try to set deadlines for each deviation / documentation in order to accelerate the process while adhering to cGMP requirements.
- Develop a value stream map related to the solid form (similar to appendix G), to the liquid forms (similar to appendix H) and to other forms available (creams, spray, suppositories…) and try to find at which stage the wastes are occuring in order to know exactly what steps to take and which tools to emphasis on more.
- In order to reduce the waiting time between steps, kanban cards can be used. These cards will include all the information required per product at each stage of the process and details what is needed in the following step.

5.2. Limitations

The research that was conducted could have been wider and representative of a larger sample if we had received the answers of more employees especially from outside the production department. This way, it would be more accurate to assess the implementation of lean manufacturing in the laboratory.

In addition, the company's secrecy prevented us from going deep into figures like the OEE results obtained since its application in the production department and this since 2012.

5.3. Further researches

In the future, it may be useful to develop a real value stream map for different products and calculate the parameters needed (changeover, taki-time, cycle time) in order to be able to identify at which stage of the production the wastes are occurring in order to know how to eliminate them as much as possible. This method needs the study of the product cycle over a long period in order for the results to be accurate. This also needs an accurate communication and coordination between departments.

This value stream map is essential and this in the different steps of a product's life cycle for a better understanding of the process and for a better introduction and assessment of lean tools usage.

It may also be interesting to compare the results between industries whether they are all pharmaceuticals or from different sectors.

Bibliography

5S / Visual Workplace Handbook - Building the foundation for continuous improvement. Production Automation Corporation.

A brief history of lean. (2012, December). Retrieved from Strategos: http://www.strategosinc.com/just_in_time.htm

Abbruzzese, J. (n.d.). SMED Quick Changeover. Windsor-Essex.

Ahrens, T. (2006). *Lean production: Successful implementation of organisational change in operations instead of short term cost reduction efforts.* Germany: Lean Alliance.

Algorithm Pharmaceutical Manufacturers. (2011). Retrieved from http://www.algorithm-lb.com

Chowdary, B., & Damian, G. (2012). Improvement of manufacturing operations at a pharmaceutical company: A lean manufacturing approach. *Emerald Group Publishing Limited* .

Conseil et Développement s.a.l. (2012, February). Retrieved 2013, from Conseil et Développement s.a.l.: http://www.condev-lb.com/?p=14

Dessus , S., & Ghaleb, J. (2006, May). Lebanon – Trade and Competition Policies for Growth: A General Equilibrium Analysis. *43*. Middle East & South Africa: The Office of the Chief Economist - The World Bank.

Engum, M. (2009, May). Implementing Lean Manufacturing into Newspaper Production Operations. USA.

FDA, U. (2009, December 12). *Good Manufacturing Practice (GMP) Guidelines/Inspection Checklist*. Retrieved June 2013, from US. Food and Drug Administration: http://www.fda.gov/cosmetics/guidancecomplianceregulatoryinformation/goodmanufacturingpracticegmpguidelinesinspectionchecklist/default.htm

Greene, A., & O'Rourke, D. (2006, September). Lean manufacturing Practice in a GMP environment. Advanstar Communications.

Grout, J. (n.d.). Value Stream. *Using Process Mapping to Identify Patient Safety Hazards in Micro-Systems - Quality and Safety in Healthcare* . Berry College.

History of lean manufacturing. (2012). Retrieved from Manufacturing-works: http://manufacturing-works.com/lean/lean_history.php

Introduction to Lean and Waste Course. (2000-2013). Retrieved January 2013, from isixsigma: https://store.isixsigma.com/product/Training-Materials--Aids/lean-six-sigma/introduction-to-lean-and-waste-course

Kim, D. (2002, August). Exploratory Study of Lean Construction: Assessment of Lean Implementation. Austin, Texas: The University of Texas at Austin.

Kovacheva, A. (2010, January). Challenges in Lean Implementation - Successful transformation towards Lean enterprose. Aarhus: University of Aarhus.

Lean Manufacturing. (n.d.). Retrieved from Wikipedia: http://en.wikipedia.org/wiki/Lean_manufacturing

Lean Methodology. (n.d.). Retrieved from Operational Excellence Consulting: http://www.operational-excellence-consulting.com/our-opex-solutions/lean-principles.html

Lebanon Trade, Lebanon Exports, Lebanon Imports. (2010, March 29). Retrieved 2013, from Economy watch - Follow the money: http://www.economywatch.com/world_economy/lebanon/export-import.html

Lee, Q. (2003, December 2). Implememnting leam manufcaturing - Imitation to Innovation. Strategos inc.

Level Load Balancing. (2013). Retrieved Jan 2013, from Quality America: http://www.qualityamerica.com/knowledgecenter/leansixsigma/level_load_balancing.asp

Lila, B. (2012). A Survey on Implementation of the Lean Manufacturing in Automative Manufacturers in the Eastern Region of Thailand. *2nd International Conference of Industrial Technology and Management. 49.* Singapore: IACSIT Press.

Maez, B. (2008). Using Lean Manufacturing and Six Sigma Conepts to Improve Quality in an Investment Casting Shell Room. California: Faculty of California State University Dominguez Hills.

Magnier, P. (2009, January 31). The Lean Enterprise - Value Stream Mapping. Release Org.

Marin-Garcia, J., & Carneiro, P. (2010). Questionnaire validation to measure the application degree of alternative tools to mass production. *International Journal of Management Science and Engineering Management , 5* (4), 268-277.

Miller, G., Pawloski, J., & Standridge, C. (2009). A Case Study of lean, sutainable manufacturing. *Journal of Industrial Engineering and Management , 3* (1), 11-32.

Nordin, N., Md Deros, B., & Abd Wahab, D. (2010). A Survey on Lean Manufacturing - Implementation in Malaysian Automotive Industry. *International Journal of Innovation, Management and Technology , 1* (4), 374-380.

Nordin, N., MD Deros, B., & Abdul Wahab, D. (2010). Relationship between organizational change and lean manufacturing implementation in Malysian automative industry. Malysia.

O'Rourke, D., & Greene, A. (2006). Lean Manufacturing practice in a cGMP environment. *Pharmaceutical Technology Europe , 18* (10).

Rother, & Shook. (2009). Value Stream Mapping.

Shetty, D., Ali, A., & Cummings, R. (2010). Survey-based spreadsheet model on lean implementation. *International Journal of Lean Six Sigma , 1* (4), 310-334.

Smart, N. G. (2010, October 21). Lean Manufacturing in the Pharmaceutical CGMP Environment. Retrieved from http://ezinearticles.com/?Lean-Manufacturing-in-the-Pharmaceutical-CGMP-Environment&id=5245421

Smart, N. G. (2010, October 28). Moving Toward Lean Manufacturing Implementation. Retrieved from http://ezinearticles.com/?Moving-Toward-Lean-Manufacturing-Implementation&id=5245363

Soueid, M., Ghanem, S., Hariri, Z., & Sayess, D. (2013). *Lebanon Weekly RepoRt.* BankMed, Market and economic Research Division.

STATUS OF THE PHARMACEUTICAL INDUSTRY IN LEBANON. (2003). Retrieved from http://www.drugavoid.com/PDF/section4.pdf

Tague, N. R. (2004). *The Quality Toolbox* (Second ed.). ASQ Quality Press.

The Directory of Exports & Industrial Firm in Lebanon. (2013). Retrieved from http://www.lebanon-industry.com/en/Default.aspx

Tinoco, J. C. (2004). *Implementation of lean manufacturing.* University of Wisconsin-Stout.

Value Stream Mapping Tools. (2012). Retrieved from Breeze Tree: http://www.breezetree.com/value-stream-mapping.htm

Viadeo - Business solutions. (2004-2012). Retrieved from http://business.viadeo.com/network-statistics/

Viswanathan, N., & Littlefield, M. (2009). *Lean Manufacturing - Five tips for reducing waste in the Supply chain.* USA: Aberdeen Group.

Vu, D. (2007). Researching and Analyzing The Cost benefits of Lean Mnaufacturing within the Medical Device Industry. California: Faculty of California state University Dominguez Hills.

Wanitwattansakosol, J., & Sopadang, A. (2012). *A Framework for implemeting Lean Manufacturing Systme in Small and Medium Enterprises.* Paper, Faculty of Engineering Chaing Mai University, Department of Industrail Engineering, Thailand.

What is lean - History. (2009). Retrieved from Lean Enterprise Institue: http://www.lean.org/whatslean/history.cfm

Yogesh, M., ChandraMohan, D., & Arrakal, R. (2012). Application of Lean in a Small and Medium Entreprise (SME) Segment - Case Study odf Electronics and Electrical Manufacturing Industry in India. *International Journal of Scientific & Engineering Research* , *3* (8).

Appendices

Appendix A: Survey

Notre Dame University

Faculty of Business Administration & Economics

Graduate Division

Survey:

Lean Manufacturing: Implementation and assessment for Lebanese firms

Case of "Algorithm Pharmaceutical Manufacturers"

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of the Master of Business Administration (M.B.A.)

MARIANNE KHLAT

NDU – Lebanon

2013

Dear participant,

As a requirement to obtain my Master in Business Administration (Degree) with a concentration of management and marketing, I am conducting a survey in "Algorithm Pharmaceutical industry" in order to understand the extent to which lean manufacturing is being applied and to evaluate the effectiveness of such concept in the firm profitability.

Please answer the questions freely. Be objective and honest. All the answers you will be giving will be treated in the strictest confidence. Please note that your opinion and comments are applicable to my thesis only and does not bind the company in implementing.

Kindly read carefully each question and check by "X" the box or circle the scale letter that best suits your opinion. This survey takes about 10 minutes to fill out.

What is the job title that you fill in the company?

Department	**Manager**	**Supervisor**	**Team member**
Production			
Engineer/Maintenance			
Quality Assurance			
Quality Control			
Materials Control			
Administration			
Others			

How many years has/have:

	0-3 years	4-7 years	8-11 years	12-15 years	16-19 years	>20 years
The company implemented lean?						
You worked in this company?						

On a scale from 1 to 5, circle the number that best indicates the level of agreement with each statement.

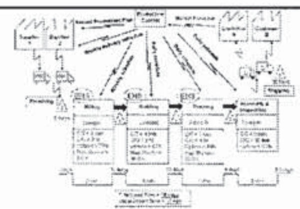
Rating Scale

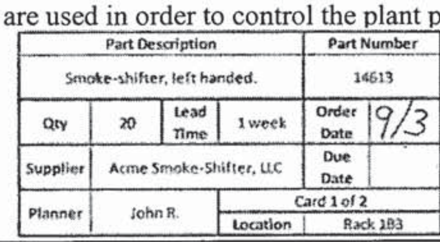
1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

	Questions / Statements	Answers				
	Section 1: General knowledge about lean Manufacturing strategy					
1	Are you familiar with the Lean Manufacturing concept?	1	2	3	4	5
2	Do you consider that your company is Lean oriented?	1	2	3	4	5
3	Did you get any training in lean principles and tools?	1	2	3	4	5
4	Has anyone been designated in each department to manage the lean thinking implementation?	1	2	3	4	5
5	Does the company rely on lean experts?	1	2	3	4	5
6	Has the employees accepted the lean approach?	1	2	3	4	5
7	Are all the employees involved in the implementation of lean?	1	2	3	4	5
8	Is the product cycle time short?	1	2	3	4	5
9	Does your team know what types of waste to eliminate during processing?	1	2	3	4	5
	Are there many non-value added activities during the whole process?					
10	a. Long time needed for documents preparation / issue	1	2	3	4	5

11	b. Long time needed for documents review after production	1	2	3	4	5
12	c. Too many records needed to complete the batch / product	1	2	3	4	5
13	d. Waiting a long time between steps of the same process	1	2	3	4	5
14	e. Long time spent on writing deviations if problems occurred	1	2	3	4	5
15	f. Long time spent on developing qualification of new equipment	1	2	3	4	5
16	g. Waiting a long time trying to find a solution to any problem encountered on a product	1	2	3	4	5
17	Do you know the advantages of lean strategy?	1	2	3	4	5
18	Did the lean principles change the organization structure?	1	2	3	4	5
19	Is waiting for multiple approvals required in the company?	1	2	3	4	5
Section 2: Facility, Operation and transactions inside Algorithm production						
20	Is the information flow simple between the different company's departments?	1	2	3	4	5
21	Does production output exceed the forecasted goals of the company?	1	2	3	4	5
22	Is the percentage of in-time delivery of goods and services low?	1	2	3	4	5
23	Is the information system inside the company computerized?	1	2	3	4	5
24	Do employees follow standard procedures while performing their daily tasks?	1	2	3	4	5
25	Does the machine work depending on the product on the line rather than being a standardized procedure?	1	2	3	4	5
26	Is the rate of defective products high?	1	2	3	4	5

27	Does the company update its procedure on a regular basis?	1	2	3	4	5
28	Is Kanban system used in the company's strategy?	1	2	3	4	5
29	Is the quality system established in the company flexible?	1	2	3	4	5
30	Is the company ISO certified?	1	2	3	4	5
31	Is there any recognition system linked to employee performance?	1	2	3	4	5
32	Is the frequency of rewards and recognition high?	1	2	3	4	5
33	Are the rewards implemented team-based?	1	2	3	4	5
34	Is the time needed before the intervention of maintenance department long in order to fix a mechanical problem?	1	2	3	4	5
35	Is the plant organized by product-dedicated equipment?	1	2	3	4	5
36	Is one product produced at a time?	1	2	3	4	5
37	Do operators work on different machines together to produce one item / one batch?	1	2	3	4	5
38	Is the amount of materials handled in the warehouse big?	1	2	3	4	5
39	Are the equipment used more sophisticated than needed for the process?	1	2	3	4	5
40	Is there a long distance between the stages of processing of the same product?	1	2	3	4	5
41	Is the frequency of reworked products high?	1	2	3	4	5
42	Is the frequency of rejected products low?	1	2	3	4	5
43	Do you usually purchase more materials than required?	1	2	3	4	5

44	Do you usually produce more products than the customers' orders?	1	2	3	4	5
45	Do you have continuous batches (campaign) running on the lines rather than switching from one type to another?	1	2	3	4	5
46	Do you wait until the end of the batch to correct defective products?	1	2	3	4	5
47	Are employees trained on their tasks?	1	2	3	4	5
48	Is the quantity of products kept in the quarantines waiting for the next stage of production / testing big?	1	2	3	4	5
49	Is the work done in the plant simple with no complex operations?	1	2	3	4	5
	Section 3: Application of the lean manufacturing tools and management impact					
	Is the company using the below lean tools?					
50	 a. Value Stream Mapping	1	2	3	4	5
51	b. 5S (Sort, Set in order, Shine, Standardize, Sustain)	1	2	3	4	5
52	c. Flow production / one piece at a time	1	2	3	4	5
53	d. Standardization	1	2	3	4	5
54	e. Total productive maintenance	1	2	3	4	5
55	The supervisor/manager support employees who come up with new ideas and take their ideas seriously	1	2	3	4	5
56	Improvement in the workplace has been established	1	2	3	4	5
57	Employees work in teams to complete their tasks	1	2	3	4	5

58	Your company applies lean tools in their daily tasks	1	2	3	4	5
59	The change-over done on equipment is a slow process	1	2	3	4	5
60	Employees are involved in making decisions	1	2	3	4	5
61	The overall work performed is standardized	1	2	3	4	5
62	At the plant, all tools and equipment are kept in their place during the production/process cycle	1	2	3	4	5
63	Managers don't take into account the operators/employees suggestions about work improvement	1	2	3	4	5
64	Each department works on its own and take its own decision	1	2	3	4	5
65	Noone takes responsibility of its mistakes and blames it on other departments	1	2	3	4	5
66	Operators may stop the line if they detect a problem or a defect in the product	1	2	3	4	5
67	Area is clean at all times	1	2	3	4	5
68	Too many procedures are established so that the work between steps is so long	1	2	3	4	5
69	Kanban cards are used in order to control the plant production  Part Description: Smoke-shifter, left handed. Part Number: 14613 Qty: 20 Lead Time: 1 week Order Date: 9/3 Supplier: Acme Smoke-Shifter, LLC Due Date: Planner: John R. Card 1 of 2 Location: Rack 1B3	1	2	3	4	5
70	Workers are trained to work fast and to reduce the time needed for their tasks	1	2	3	4	5
71	Managers give high priority to quick work	1	2	3	4	5
72	Every day/week, a work schedule is given to employees referring to the tasks to be performed during this period	1	2	3	4	5

73	This schedule is fixed and doesn't take into account the troubleshoots or problems that may occur during the run	1	2	3	4	5
74	The "taki time" is calculated for each production cycle $TakiTime(TT) = \frac{Availableproductiontime}{Tataldailyquantityrequired}$	1	2	3	4	5
75	Machines are grouped according to the product family	1	2	3	4	5
76	Machines and workstations are close to each other so that the movement becomes easier between departments and delay is reduced	1	2	3	4	5
77	Preventive maintenance is performed on machines on a routine basis	1	2	3	4	5
78	Maintenance department perform the work alone and don't let employees perform preventive maintenance on their machines	1	2	3	4	5
79	Regulations are established so that creative ideas are supported	1	2	3	4	5
80	Information is only shared among managers and among some key personnel in the company	1	2	3	4	5
81	Some workers only have access to information	1	2	3	4	5
82	Managers who are not cooperating for lean are eliminated	1	2	3	4	5
83	The quality of airflow, light and noise is not safe	1	2	3	4	5
84	Employees are satisfied with their jobs	1	2	3	4	5
85	Teams receive regular feedback from their supervisor about their work performance	1	2	3	4	5
86	All workstations contain standard operation procedures (SOP)	1	2	3	4	5
87	Your job is considered to be standardized	1	2	3	4	5
88	The company has PCs on the production floor to control each step of the production	1	2	3	4	5

89	A Value Stream Map is developed	1	2	3	4	5
	Section 4: Evaluate the effect of the lean manufacturing tools:					
90	The standardization increased the effectiveness and efficiency of the work inside the company	1	2	3	4	5
91	Employees encounter problems while applying a standardized activity	1	2	3	4	5
92	The lean principles change the whole organization structure	1	2	3	4	5
93	At the plant, graphs are installed near the machines to indicate the run-down times	1	2	3	4	5
94	At the plant, graphs are installed near the machines to indicate the number of defective items obtained from the run	1	2	3	4	5
95	At the plant, graphs are installed near the machines to indicate the production level	1	2	3	4	5
96	Alarms and sings indicate if there is any deviation or problem on the line	1	2	3	4	5
97	Too many procedures are established so that the work between steps is so long	1	2	3	4	5
98	Efforts are made by the departments to reduce the size of the production batches	1	2	3	4	5
	Since the application of lean, company has noticed:					
99	a. Lack of Management commitment	1	2	3	4	5
100	b. Knowledge about the tools	1	2	3	4	5
101	c. Employee resistance to change	1	2	3	4	5
102	d. Lack of resources	1	2	3	4	5
103	e. Change in the culture of the company	1	2	3	4	5

104	f.	Reduction of non-value added activities	1	2	3	4	5
105	g.	Waste reduction	1	2	3	4	5
106	h.	Increase efficiency and productivity	1	2	3	4	5
107	i.	Quicker change-overs	1	2	3	4	5

Thank you for taking time to complete this survey.

Appendix B: Repartition of the survey questions

- Questions 1, 2, 3, 4, 5, 9 and 17 were used to test how well employees and managers know about the lean manufacturing tools in general.
- Questions 6, 7, 31, 32, 33, 47, 55, 57, 60, 63, 64, 65, 66, 70, 79, 80, 81, 82, 84 and 85 will be assigned to the employee involvement variable (kaizen) which is an independent variable.
- Questions 20, 23, 24, 25, 27, 29, 30, 35, 36, 37, 49, 51, 53, 56, 61, 62, 67, 75, 86, 83 and 87 will be assigned to the standardization variable that will also include the work flow and the 5S cleaning instructions as they are also related to well standardized process. This is also an independent variable.
- Questions 8, 10, 11, 12, 13, 14, 15, 16, 19, 21, 22, 28, 34, 38, 40, 43, 44, 45, 46, 48, 50, 52, 59, 68, 69, 71, 72, 74, 76, 88, 89, 93, 94, 95 and 98 will be assigned to the Just-in-time variable which is also an independent variable.
- Questions 39, 54, 73, 77, 78 and 96 will be assigned to the total productive maintenance variable, which is also an independent variable. Question 78 was omitted from the survey, as it was not answered by most of the participants.
- Questions 26, 41 and 42 will be assigned to the defects variable, which is an independent variable. This variable was omitted as it decreased the consistency of the results. It is probably linked to the fact that operators, even managers can't assume at what level of defects we start by stating that the amount of defects is high or the amount of rejected products is high.
- Questions 18, 58, 90, 91, 92, 97, 99, 100, 101, 102, 103, 104, 105, 106 and 107 will be related to the dependent variable to be tested which is the lean manufacturing effectiveness on production.

Appendix C: Focus group with Production team members

The meeting was held in Algorithm's company, in the Production department and it treated the following questions:

Interviewer: Marianne Khlat

Interviewee: 8 team members

Duration: 1 hour

Q1: As team members in a big department, where lean is starting to being implemented, to which extent do you feel that lean is applicable in production?

Q2: In a world where there is always evolution and new technologies that are frequently introduced, to what level do you prefer stability to change? How did you deal with the change of lean implementation?

Q3: How do you see the advantages of such strategy on the overall productivity?

Q4: Have you noticed any improvement in your performance since the implementation of lean?

Q5: What specific tools do you use for that purpose? Are you aware of these issues?

Q6: How were you introduced to this concept?

Q7: Do you feel that you are comfortable at work or do you come nervous and tense?

Q8: Does your manager/supervisor encourage you to be creative and to come up with new ideas?

Q9: Do you feel well appreciated and appraised?

Q10: If you were to be more appreciated, will this increase your productivity and make you more motivated?

Q11: Do you think that when your work is done is a standardized way, this will ameliorate the output so you can work better?

Q12: What activities / documentations are delaying the production cycle?

Q13: Do you feel that these delays are the reason behind the decrease of the productivity?

Q14: What about total productive maintenance? What is the link existing between TPM and productivity?

Q15: GMP requires that area should be cleaned at all time. Do you think that there's a relation between the environment status and the productivity?

Appendix D: Depth-interview with the Production Supervisor

The interview was held in Algorithm's company, in the Production Manager office and it treated the following questions:

Interviewer: Marianne Khlat

Interviewee: Production Supervisor

Duration: 30 minutes

Q1: As a supervisor in a big department, where lean is starting to being implemented, to which extent do you feel that lean is applicable in production?

Q2: In a world where there is always evolution and new technologies that are frequently introduced, to what level do you prefer stability to change? How did you deal with the change of lean implementation?

Q3: How do you see the advantages of such strategy on the overall productivity?

Q4: Have you noticed any improvement in the employees' performance since the implementation of lean?

Q5: What specific tools do you use for that purpose? Are employees aware of these issues?

Q6: How were employees introduced to this concept?

Q7: Do you feel that these employees are comfortable at work or do they come nervous and tense?

Q8: Do you encourage your subordinates to be creative and to come up with new ideas or you prefer that the work is done as already planned?

Q9: Do you think that standardization in the work place is directly linked to the productivity of the firm?

Q10: What activities / documentations are delaying the production cycle?

Q11: Do you feel that these delays are the reason behind the decrease of the productivity?

Q12: What about total productive maintenance? What is the link existing between TPM and productivity?

Q13: GMP requires that area should be cleaned at all time. Do you think that there's a relation between the environment status and the productivity?

Appendix E: Linear regression test results (as generated by "SPSS")

Table 19: Reliability of the linear regression by "SPSS" (by position)

Model Summary[b]

Group	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
						R Square Change	F Change	df1	df2	Sig. F Change
1	1	.772[a]	.595	.416	.288	.595	3.311	4	9	.063
2	1	.727[a]	.529	.492	.393	.529	14.316	4	51	.000

a. Predictors: (Constant), Standardization (and 5S), Kaizen, Total Productive Maintenance (TPM), Just-in-time (JIT)

b. Dependent Variable: Effectiveness

Table 20: Anova of the linear regression by "SPSS" (by position)

ANOVA[a]

Group	Model		Sum of Squares	df	Mean Square	F	Sig.
1	1	Regression	1.098	4	.275	3.311	.063[b]
		Residual	.746	9	.083		
		Total	1.844	13			
2	1	Regression	8.833	4	2.208	14.316	.000[b]
		Residual	7.867	51	.154		
		Total	16.700	55			

a. Dependent Variable: Effectiveness

b. Predictors: (Constant), Standardization (and 5S), Kaizen, Total Productive Maintenance (TPM), Just-in-time (JIT)

Table 21: Correlation of the linear regression by "SPSS" (by position)

Coefficients[a]

Group	Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
			B	Std. Error	Beta			Lower Bound	Upper Bound
1	1	(Constant)	-.202	.959		-.211	.838	-2.373	1.968
		Kaizen	.457	.340	.400	1.342	.212	-.313	1.227
		Just-in-time (JIT)	.395	.622	.255	.634	.542	-1.013	1.802
		Total Productive Maintenance (TPM)	.137	.173	.205	.792	.449	-.254	.528
		Standardization (and 5S)	.126	.270	.150	.464	.653	-.486	.737
2	1	(Constant)	-.621	.699		-.890	.378	-2.024	.781
		Kaizen	-.168	.163	-.139	-1.028	.309	-.496	.160
		Just-in-time (JIT)	.388	.306	.178	1.269	.210	-.226	1.003
		Total Productive Maintenance (TPM)	.348	.122	.323	2.847	.006	.103	.594
		Standardization (and 5S)	.529	.135	.459	3.913	.000	.258	.800

a. Dependent Variable: Effectiveness

Table 22: Reliability of the linear regression by "SPSS" (by expertise)

Model Summary[b]

Expertise	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
						R Square Change	F Change	df1	df2	Sig. F Change
0-3 years	1	.794[a]	.630	.556	.420	.630	8.510	4	20	.000
4-7 years	1	.698[c]	.487	.385	.320	.487	4.751	4	20	.007
8-11 years	1	.986[a]	.972	.916	.243	.972	17.351	4	2	.055
16-19 years	1	.999[c]	.998	.990	.026	.998	129.884	4	1	.066
>20 years	1	.973[a]	.946	.732	.201	.946	4.411	4	1	.341

a. Predictors: (Constant), Total Productive Maintenance (TPM), Kaizen, Standardization (and 5S), Just-in-time (JIT)

b. Dependent Variable: Effectiveness

c. Predictors: (Constant), Total Productive Maintenance (TPM), Kaizen, Just-in-time (JIT), Standardization (and 5S)

Table 23: Correlation of the linear regression by "SPSS" (by expertise)

Coefficients[a]

Expertise	Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
			B	Std. Error	Beta			Lower Bound	Upper Bound
0-3 years	1	(Constant)	.219	1.163		.188	.853	-2.207	2.644
		Just-in-time (JIT)	.201	.502	.070	.400	.693	-.846	1.249
		Standardization (and 5S)	.326	.190	.293	1.717	.101	-.070	.722
		Kaizen	-.272	.241	-.187	-1.130	.272	-.775	.230
		Total Productive Maintenance (TPM)	.584	.173	.550	3.384	.003	.224	.944
4-7 years	1	(Constant)	1.527	.895		1.706	.104	-.340	3.395
		Just-in-time (JIT)	-.218	.344	-.126	-.634	.533	-.935	.499
		Standardization (and 5S)	.705	.203	.771	3.471	.002	.282	1.129
		Kaizen	-.030	.222	-.026	-.136	.893	-.493	.432
		Total Productive Maintenance (TPM)	-.054	.170	-.070	-.316	.755	-.408	.300
8-11 years	1	(Constant)	-8.304	2.482		-3.346	.079	-18.983	2.376
		Just-in-time (JIT)	5.500	3.257	1.442	1.688	.233	-8.515	19.514
		Standardization (and 5S)	.241	.895	.158	.270	.813	-3.608	4.091
		Kaizen	-1.866	1.817	-.838	-1.027	.412	-9.683	5.950
		Total Productive Maintenance (TPM)	.299	.533	.259	.561	.631	-1.996	2.594
16-19 years	1	(Constant)	.557	.142		3.917	.159	-1.249	2.362
		Just-in-time (JIT)	.742	.069	.773	10.757	.059	-.134	1.618
		Standardization (and 5S)	.155	.051	.292	3.068	.201	-.488	.799
		Kaizen	-.033	.066	-.037	-.499	.705	-.869	.803
		Total Productive Maintenance (TPM)	.032	.035	.082	.910	.530	-.415	.479

>20 years	1	(Constant)	-.507	1.072		-.474	.718	-14.124	13.109
		Just-in-time (JIT)	1.301	.760	.948	1.712	[redacted]	-8.356	10.958
		Standardization (and 5S)	.096	.283	.136	.339	[redacted]	-3.494	3.685
		Kaizen	-.014	.346	-.019	-.042	[redacted]	-4.415	4.386
		Total Productive Maintenance (TPM)	-.083	.291	-.100	-.285	[redacted]	-3.783	3.618

a. Dependent Variable: Effectiveness

Appendix F: Chi-Square test results (as generated by "SPSS")

Table 24: JIT Chi-Square test by "SPSS"

Chi-Square Tests

Group		Value	df	Asymp. Sig. (2-sided)
1	Pearson Chi-Square	129.500	121	.282
	Likelihood Ratio	62.803	121	1.000
	Linear-by-Linear Association	6.446	1	.011
	N of Valid Cases	14		
2	Pearson Chi-Square	656.749	576	.011
	Likelihood Ratio	243.843	576	1.000
	Linear-by-Linear Association	4.011	1	.045
	N of Valid Cases	56		

Table 25: Standardization Chi-Square test by "SPSS"

Chi-Square Tests

Group		Value	df	Asymp. Sig. (2-sided)
1	Pearson Chi-Square	116.667	99	.109
	Likelihood Ratio	58.984	99	1.000
	Linear-by-Linear Association	3.393	1	.065
	N of Valid Cases	14		
2	Pearson Chi-Square	641.378	504	.000
	Likelihood Ratio	224.403	504	1.000
	Linear-by-Linear Association	23.949	1	.000
	N of Valid Cases	56		

Table 26: Kaizen Chi-Square test by "SPSS"

Chi-Square Tests

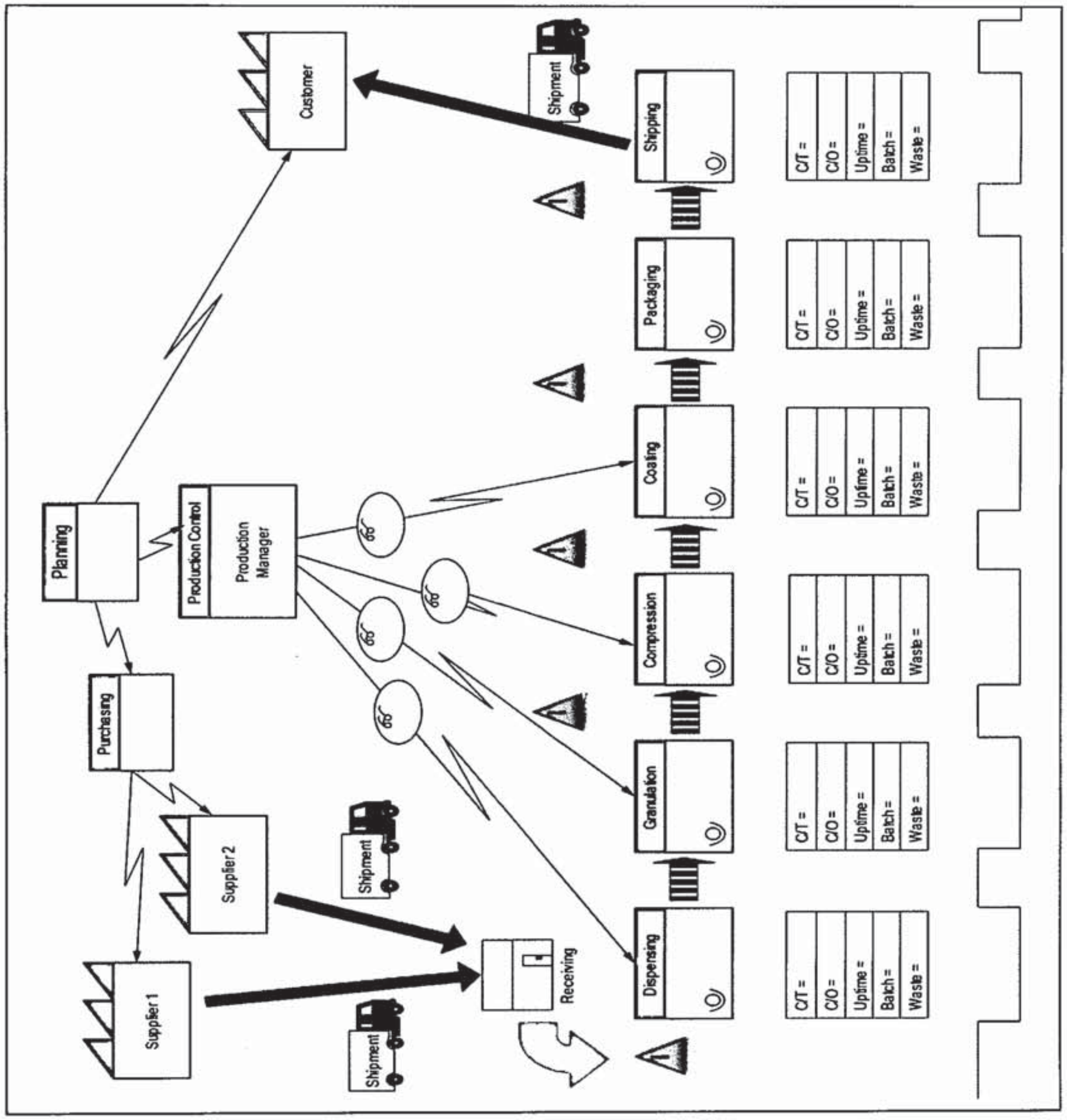
Group		Value	df	Asymp. Sig. (2-sided)
1	Pearson Chi-Square	129.500	121	[redacted]
	Likelihood Ratio	62.803	121	1.000
	Linear-by-Linear Association	4.913	1	.027
	N of Valid Cases	14		
2	Pearson Chi-Square	689.911	624	[redacted]
	Likelihood Ratio	246.307	624	1.000
	Linear-by-Linear Association	.357	1	.550
	N of Valid Cases	56		

Table 27: TPM Chi-Square test by "SPSS"

Chi-Square Tests

Group		Value	df	Asymp. Sig. (2-sided)
1	Pearson Chi-Square	77.000	77	[redacted]
	Likelihood Ratio	50.666	77	.991
	Linear-by-Linear Association	2.703	1	.100
	N of Valid Cases	14		
2	Pearson Chi-Square	310.516	264	[redacted]
	Likelihood Ratio	148.194	264	1.000
	Linear-by-Linear Association	18.872	1	.000
	N of Valid Cases	56		

Appendix G: Value Stream Mapping for tablet Forms



Appendix H: Value Stream Mapping For liquid forms