# Inventory management optimization using lean six-sigma
## Case of Spare parts Moroccan company

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### *Abstract*

Since the economic crisis has begun, every organization search for solutions that allows firms to gain competitive advantage. For this reason, almost of companies search to improve their management, one way for this is lean management. In this paper we focus on the second muda of lean management, to produce for the customer the exact quantity needed. This result on eliminating excess stock or shortage wastes. For the Moroccan firms who are self financing, they focused more on the search for new methodologies that allow them enhancing their financial results by decreasing costs and improving their process and customers satisfaction. In this paper we choose to apply lean six-sigma for the calculation of inventory, using DMAIC. The proposed model is tested in a Moroccan spare parts company. Firstly, we have identified the inventory management problems and secondly we measure the data of these problems. In the third part we find out the root causes and finally find solutions to improve and control.

### Keywords

Lean management; inventory management; six sigma; dmaic

## I- INTRODUCTION

The lean management is a way to make the best work with less effort, to optimize resources. This management method is for continuous improvement, based on eliminating wastes, named in Japanese muda. (Womack, Jones)
The seven types of waste are the over production, Inventory, waiting time, transport, Process, Motion, Defectives. (Slack & Chambers & Johnston 2010)

In the other side, the six-sigma is Motorola's registered trademark designating a structured management approach to improve the quality and efficiency of the process. The Six Sigma method was applied to the industrial process before being extended to all types of processes. It has grown considerably due to the complexity of organizations and the internalization of the process that impose a global vision of problems.

The combination of using lean is to eliminate waste and six-sigma to improve quality.

For the implementation of lean six-sigma, the USA is the country leader for the application, followed by Canada, UK and European countries. For underdeveloped and developing countries, there is a lack of interest for this subject. (Cherrafi & al 2016)

In this paper, we have chosen to apply the six-sigma to the second muda: the inventory for spare parts Moroccan company.

For the inventory it's the stock needed to satisfy customer demand; the purpose is to define the amount to keep in stock (Russell & Taylor, 2010) And for the reputation of the Lean Six Sigma, the consulting firms that propagate it, are all factors that have encouraged the enthusiasm of Moroccan companies to set up such management instruments that will enable to improve their own companies (WAHABI & Al 2015)

We used one of the key methodologies of six- sigma is DMAIC; this tool is for quality strategy for improving processes used to improve existing process.

The first step using this methodology is defining the problem of excess and shortage for inventory or the goal of stock optimization that needs to be addressed.

The second step is measuring the problem of inventory and process from which it was produced.

The third step is Analyzing data of each part and process to determine root cause and opportunities of shortages and excess stock.

The firth step is improving the process by finding solutions to eliminate the key root causes in order to fix and prevent the inventory problem. The final step is controlling the results to ensure sustainable and continued improvement.

## II- LITERATURE REVIEW

The concept of lean management was known through the book 'the machine that changed the world" on 1990, the lean was a tool for reducing wastes (Womak & Al 1990). Wastes are anything other than the essential of adding value to products; using the minimum of equipment, materials, parts, space and time (Russell & Taylor, 2010). Many companies invest for improvement and flexibility using lean tools (Manzouri & al 2014) The practices more used in companies is 5S, TPM and work standardization (Alhuraish & al 2015)

Six-Sigma is a structured method to improve quality by reducing variation in organizational processes by using improvement specialists, and performance indicators to achieve the strategic objectives (Linderman & Al 2003)

The Six Sigma DMAIC method is a methodology for project management approach to measure and find solutions for a specified process. (FAN & Al 2015) But there is a disconnection between the education and theory of the six-sigma and the real application in the work marke (Chen & Al 2014).

Seven forms of wastes are identified, transport, inventory, motion, waiting, over processing, overproduction, and defects. We combine here between the six-sigma methodology and one of the wastes, the inventory. Taking in consideration that this methodology is important to define the defects and the exact time in the supply chain management (Erbiyik, Saru 2015)

For the Lean six-sigma, the majority of literature is from USA, but their culture is different from European and African one. This fundamentals influence the lean six-sigma implementation in companies. (WAHABI & Al 2015)

For specific industries and processes, there is a lack of measuring and testing methods and models, this variation of industries need specific indicators (Cherrafi & al 2016), also the detailed research using six-sigma and explaining the way of improvement for organizations are limited (Sin & al 2015).

## III-    METHODOLOGY OF THE STUDY

The six-sigma has as goal the improvement of quality and eliminate defects. One of the methodologies of six-sigma is DMAIC, applied for the improvement of existing process, using steps defined helping to obtain effective results. There are five level steps for the application of six-sigma to improve the quality of output.

### 1- Define

It's the first step of DMAIC, essential for the success of six-sigma project. It is therefore important to define which problem to cover first in order to obtain the best possible results. To do this, the process must be clearly defined by mapping it using the

SIPOC (Supplier, Input, Process, Output and Customer) tool in order to detect anomalies or malfunctions more easily. To understand better a high level process, we can use this diagram (Tenara, Pinto 2014)

For supplier input process output customer (SIPOC), we identify the suppliers, the entrance from supplier, the intern process, then the outputs and finally the costumers.

In this phase also, the goal is clarified and the real value for project is selected. Companies could search first for cost reduction, without taking in consideration the demand of customer that's why the goal is obtained from customer expectation.

## 2- Measure

In this step the data are collected to understand more the process to find the root cause of the problem and obtain the bases for the study to analyze it in the next phase.

After the problem detection in the first step, it's now necessary to focus more on the quantification of these problems and to be able to collect data in order to obtain figures, statistics and trends.

It is therefore essential to gather information on the current situation of the processes, in order to determine the degree of distance from the new objectives and also to obtain a baseline which can be used throughout of the DMAIC approach.

The six-sigma is based on the achievement of very specific objective, so it is essential to be able to assess at what stage the company is located and then at what rate closer to its objectives

It is important to understand the process that needs to be improved and which is at the heart of the DMAIC approach, which is why it is useful at this stage of mapping well. A simple mapping has normally already been defined during the first phase but it is necessary to deepen it further during the phase of measurement, in particular by obtaining more information on the delays, the different stages. Also, it should allow the members of the company to better understand the process in its entirety, to identify the elements that contribute to the inefficiency of the process and thus to have a detailed overview.

The data collected should help the company understand why it is not achieving the desired results. It is therefore necessary to gather as much information as possible in order to better understand the problem, but it is also not necessary to quantify everything. The subtlety of this phase is therefore to determine the nature of the relevant data to be taken into account as not all parameters are involved in data collection. In particular, it is necessary to sort out the different "inputs" that have the potential or not to have a real impact on the process and the results of the company. Indeed, only the most appropriate data must be collected in order not to complicate an already complex process. It is unnecessary to collect data that is not exploitable and that lose money. When we get the information, it is time to determine how these data will be collected.

To better understand the processes and study their evolution, we must choose a specific data collection system on which to base our research. These methods should be applicable throughout the project in order to allow a proper evaluation of the evolution of the latter at different stages. The selected tools will also depend on the data types previously selected. It must also be ensured that the measurements give precise results, of consistent and homogeneous quality. Reproducibility tools are therefore particularly relevant for testing potential measurement systems.

## 3-         Analysis

This third phase of the DMAIC is fundamentally related to the previous one because it involves analyzing the data that was collected during the measurement stage. Using these data, it is easier to identify the source of the problem and to quantify the gap between the current situation and the desired situation, in particular by means of graphic and analytical tools which make it possible to highlight deviations. The previous phase gathered information on processes to better understand the origin of the problem and it is now necessary to analyze these data and transform them into statistics, trends and visual graphs in order to clarify the relationships between the different elements of the process.

Without this analysis phase, the process is incomplete, This is why it is important to use the data gathered in order to better understand how incoming elements are transformed into outgoing elements and what level of the process prevents the company from obtaining better results.

The mapping done in the previous phase allows teams to better understand the details of each step in the process and to highlight inefficient gaps or steps that do not contribute anything. However, the analysis phase is crucial because it allows going even further, not to be influenced by superficial causes but to analyze the information in detail and in depth so that the modifications carried out within the framework of DMAIC projects can have the greatest impact. The objective is not to solve a problem superficially, and thus to benefit from an interim solution, hoping that it will work as long as possible, but to carry out a thoughtful analysis, to identify trends and Relations of cause and effect, thus allowing to find the root causes of the problems.

The analysis should also facilitate the sharing of figures and discoveries, highlighting key information. As a result of the implementation of this third phase of DMAIC, relevant data and analyzes are available which will enable the fourth phase of "innovation" to be initiated, which consists in identifying and implementing innovative solutions.

## 4-        Improve and Control

At this stage, the source of the problem has normally been clearly identified. This step not only defines solutions but also tests them, to ensure their viability, and then find ways to implement them in the most appropriate way possible. We will then begin by explaining the research approach of the best solutions, then the execution of various tests to determine which solutions are the most relevant before we look at their implementation.

We have to take in consideration the current situation, and the desired situation must be taken into account in order to make relevant decisions that will have the greatest impact. Depending on the conclusions reached in the early stages, the problem can be solved easily if it is a common problem.

It is necessary to assess the potential of each solution. To do this, it is possible to carry out simulations, to study the feasibility of the project.

For a DMAIC project to be effective, it is necessary to plan an implementation plan to implement the solutions. It is not enough to find solutions, it is necessary to be able to implement them correctly. In general, the solutions that are adopted within the framework of the Six Sigma are associated with profound transformations in the process of a company. This means that it is necessary to take many aspects into account, in particular in terms of potential costs, timelines and the definition of those responsible. Following the implementation of the most suitable solutions, it is possible to proceed to the fifth control step.

## 5-  Control

The fifth step of the DMAIC approach is a monitoring and follow-up phase. It comes right after the improvement phase which enabled the implementation of the new selected solutions, following the in-depth study of certain quality problems in the company. This stage is complex in that it should enable the teams to compare a desired new situation with an initially unsatisfactory situation and thus observe the current situation in order to confirm and maintain the success of the DMAIC project. It is during the control phase that it is particularly important to properly document the project, in particular by revising and updating the process maps developed during the DMAIC project so that they reflect the actual situation of the project. At this stage of the project, it is easier to observe the actual results that result from the new solutions implemented and transform them into information relevant to the company. The DMAIC project must therefore be translated as clearly and simply as possible so that all members of the company can refer to it at any time without difficulty. This step allows us to go back on the details and the specificities of the project, to describe the results, to discuss the relevant findings that were discovered in the early stages of the DMAIC and that could be exploited in future projects within The Company.

In this phase it is also important to anticipate how the company should respond to potential problems highlighted by control plans. Defining reaction plans must therefore make it possible not to be taken aback and even to take preventive measures whenever possible. The team must then plan what actions to take, what types of tools to use and have a general idea of the behavior to adopt in order to react as soon as a problem is identified.

The solutions implemented must be maintained so that they do not disappear as weeks, months and even years go by. This can be accomplished through a variety of measures, including monitoring and tracking processes and identifying gaps early enough to take corrective action as quickly as possible.

## IV- RESULTS AND DISCUSSION

## 1-  Define

The company studied in this paper, is a Moroccan firm of engine spare parts, for this first step, we define the process of inventory with SIPOC. This cartography is showing the different category of suppliers classified by product family, the entrance to the company, beginning from the customer order, and the reception of parts the intern process to the output and the expedition to different customer.
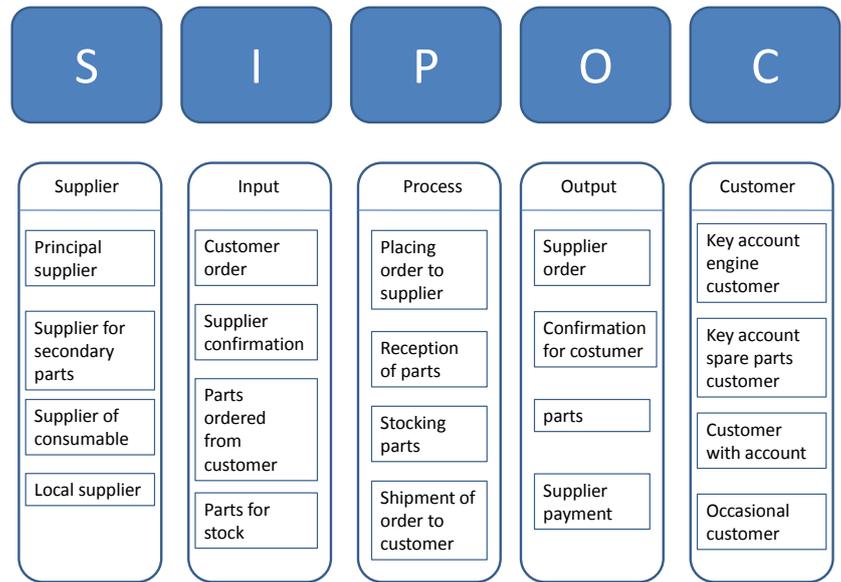
Figure 1: SIPOC cartography

For this company, self financed; the decision of stocking is increasing the working capital. For the Moroccan company the stock is taking in general between 10% and 40% of the Working Capital (Russell & Taylor, 2010), for the case we have studied, the stock is taking 50% of the working capital.

In the other side, the majority of their suppliers is in Europe, so there is more risk of variable costs and lead time.

So there is balance between having high level of customer satisfaction even if it's increasing the working capital, or risking shortages and decreasing the customer satisfaction.
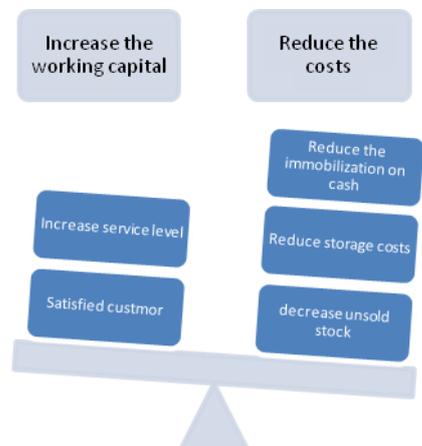


Figure 2: Balance between working capital and cost reduction

## 2- **Measure**

For the case studied in this paper, we have taken 952 sales lines, in the histogram below; we can observe that number of parts in stock is more important than what's in order from supplier. Also the number of parts ordered from supplier is more important than ordered from customers. For this apparent exceeding stock there is no warranty for don't having shortages.
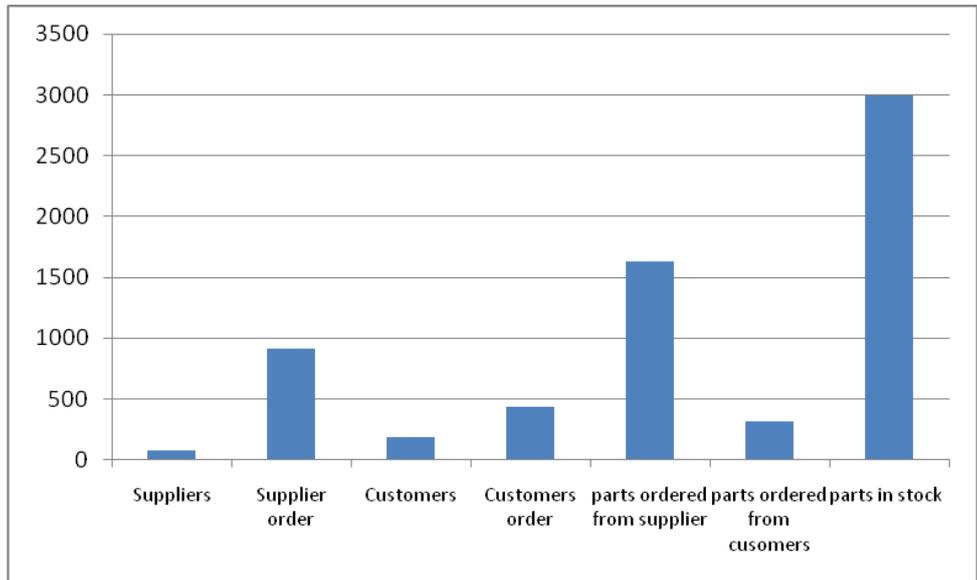
Figure 3 – Key metrics of inventory management for last year

For tha graph below, we can see that the dead stock is representing 38% percent of stock and the rotating stock with an acceptance of one year of rotation rate the percentage is 31%.
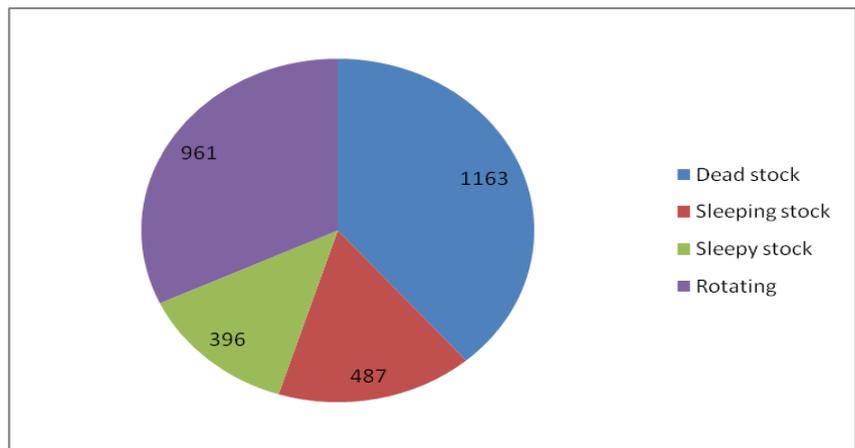


Figure 4 – Graph stock repartition

In all this data, we can note a poor quality with excess stock, shortages and delay of delivery
For the company there is a lack of data showing the number of order missed and order sold to customer with a delay of delivery

## 3- **Analysis**

For this step we used fish bone diagram, using this methodology resume, show and analyze the root causes of inventory problem. The different causes of this problem are resumed in five categories, methods, machines, man, materiel, and environment. The goal is to know why the company have this inventory issue, because of the excess stock and shortages, this is can happen because of error in the part ordered, in counting during annual inventory and if there is any change of nomenclature. The customer is not satisfied because of failure of forecasting, logistic management, ordering with the absence of standard and analyzed procurement policy and shortages due to supplier's issues. From this causes, we can have an action plan, and recommendations for company improvement.
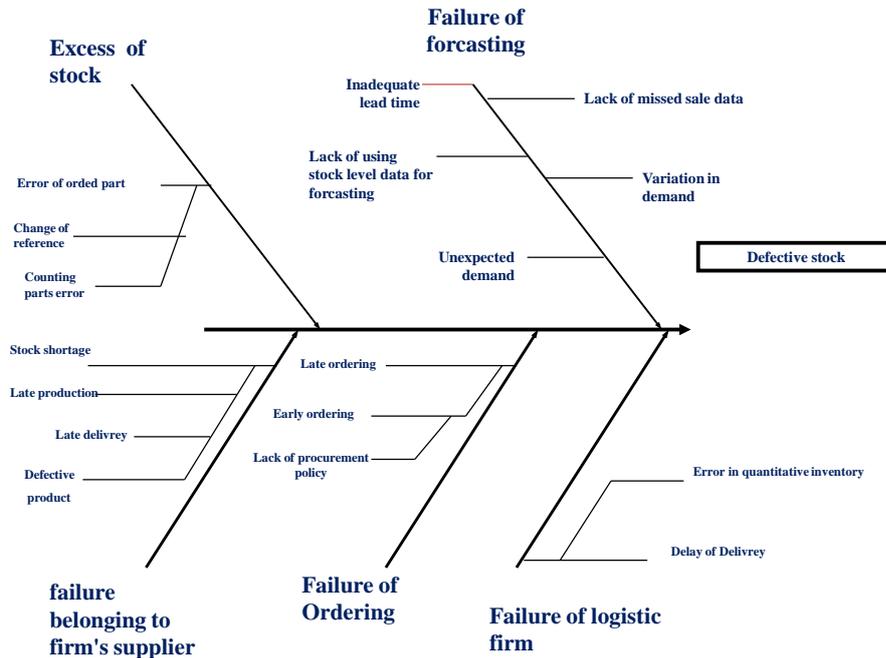
Figure 5 – Fish bone diagram

## 4- Improve and control

In this improvement phase, we present recommendations that can help company to achieve the goal of inventory optimization , The priority for this is the customer satisfaction; but the worst issue for this customer is production breakdown and shutdown of machines. For this we recommend to establish in collaboration the technical service the critical parts that can cause the shutdown of machine in case of shortage. Secondly, for the analysis we missed the data for shortages that's why they have to register the missed order to measure the customer dissatisfaction, and also to take it in consideration for the forecast. For this year we began to register the missed sales and analyze it per product family.
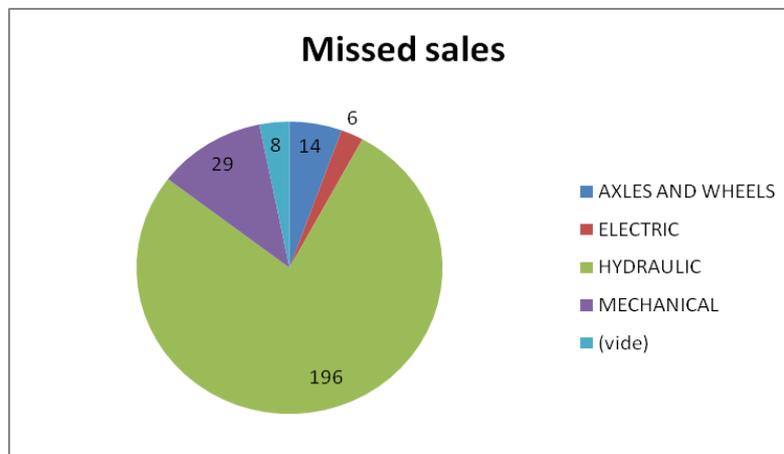


Figure 6 – Missed sales per family

After, they have to remove the specific demand from the historical data and then from the forecast.
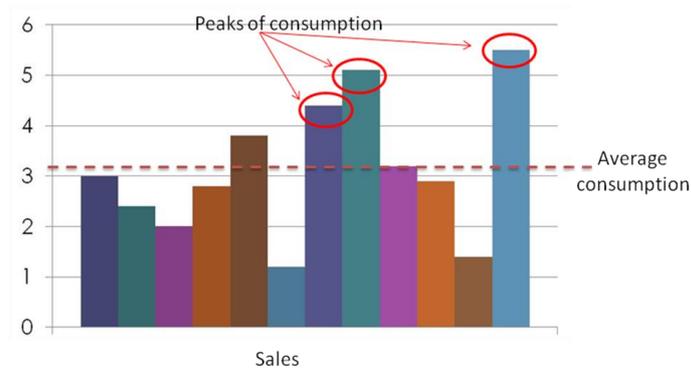


Figure 7 – Peak of consumption

They have also to negotiate the reduction of lead time, permitting in the same time to satisfy customer in the best delay for non stocked parts and have a reduction of stock, to negotiate the possibility of parts return to supplier to reduce the existing excess stock. And finally, the parts to be stocked and their quantity must be decided taking the ABC classification of customer and ABC classification for parts demand.

To control the application for these recommendations and follow improvement we can implement the following key indicator, sales of critical parts, number and value of missed orders, turnover rate, evolution of supplier lead time, number and value of parts returned to supplier, number and value of sold parts

**CONCLUSION**

The present article presented method for inventory optimization using Lean Six- Sigma (LSS) project management applied in Moroccan engine spare parts company. The Lean six-sigma proposed approach is DMAIC.

Like many Moroccan companies, there is a lack of knowledge or application of lean management and six-sigma. The first thing was to be able to present these methodologies and show their benefices for all the management of company and finally to convent them to apply the final recommendations for improvement.

During the implementation of DMAIC proposal and taking in consideration the nature of data available for project management, some classical six-sigma tools have been tested and adapted.

Through this approach, the study results showed that the improvement of process and project management can be achieved by identifying, analyzing and continuously seeing opportunities for improvement in processes and decisions while opting for resources and eliminating losses.

In this study, the data was collected from the historical customer demand for the three last year causes, the cause of waste was found, analyzed and causes have been evaluated with fish-bone diagram. Finally, recommendation was given to the company for improvement and control. This is an opportunity to apply these tools for best improvement in other process.

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