SIX SIGMA: TOOLS AND METHODOLOGY FOR THE CLOTHING INDUSTRY

Dragoş MICU[1]

ABSTRACT
This paper wants to bring forth the concept of Six Sigma and present it in an easy to comprehend manner, and see if and how it can be used in the clothing industry. Furthermore, after the methodology and tools are presented, readers can see a Six Sigma project simulation on a clothing factory and what it involves. The clothing industry has been selected as an example because there are many factories in Romania that work in this field, factories that need to lower their costs in order to stay alive but do so by mass layoffs and reducing production capacity.

KEYWORDS: *DMAIC, efficiency, quality, six sigma, performance*

JEL CLASSIFICATION: *L23, M10, M11*

1. INTRODUCTION

As the economic crisis made its presence felt, businesses all over the world noticed a significant decrease in sales, be they goods or services. Thus, many businesses tried to lower their costs, which lead to lower quality in many cases. For example many textile factories moved where manpower was cheaper and in most cases unqualified, thus resulting in lower quality products. Customers not liking the quality offered, started to buy less and less and it led to a vicious circle.
The concept of six sigma is one that apparently seems contradictory: lowering costs by improving quality. Thanks to Art Sundry's (Motorola senior executive in the 1970s) criticism of Motorola's bad quality products, the company discovered the relation between the increase of quality and the decrease of production costs. Thus, in 1986 Bill Smith, a engineer at Motorola, formulated the principals of Six Sigma methodology inspired by previous quality methodologies such as quality control, Total Quality Management (TQM) and zero defects, based on the work of previous researchers in the field such as Deming, Juran, Crosby, Ishikawa and others.
Sigma, σ, is a Greek alphabet letter used in statistics to measure the variability of a process. Thus a company's performance level is given by the sigma level of its business processes. Most companies are running at 3 or 4 sigma level and are usually spending between 15 and 25 percent of their revenues fixing problems (Krishnaraj G., 2012). This is known as the cost of quality, or better said the cost of poor quality. Businesses operating at Six Sigma level usually spend less than 5 % of their total income fixing the arising problems (as shown in Figure 1).
Further we will talk about the working principles of Six Sigma, the benefits that arise from its use and how it can help companies, in this case the ones in the clothing industry.

[1] Ph.D. Student, The Bucharest University of Economic Studies, Romania, micuvdragos@gmail.com

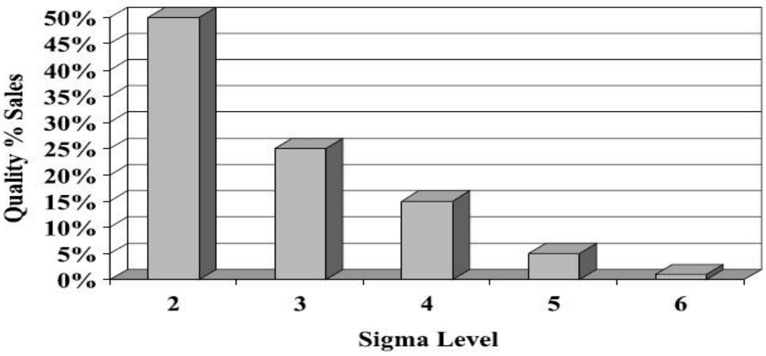

Figure 1. Cost of poor quality versus Sigma level
Source: Pyzdek and Keller (2009), p. 6

2. SIX SIGMA METHODOLOGY AND TOOLS

First of all, let's start with a few claims of world renowned companies about what Six Sigma did for them. General Electric profited between 7 to 10 billion dollars from using six sigma in about 5 years; Dupont added 1 billion dollars to its bottom line within 2 years of initiating its six sigma program, and that number increased to about 2.4 billion dollars within four years; Bank of America saved hundreds of millions of dollars within three years of launching Six Sigma, cut cycle times by more than half and reduced the number of processing errors by an order of magnitude; Honeywell achieved record operating margins and savings of more than 2 billion dollars in direct costs; and Motorola, the place where Six Sigma began, saved 2.2 billion dollars in 4 years (Pande et al., 2003).
This paper starts from the hypothesis that Six Sigma is a methodology that can help companies lower their costs or obtain higher profit margins by improving their processes.
Therefore, Six Sigma helps organizations achieve breakthrough improvement in value for themselves and their customers. Most of the companies accept between 3 or 4 sigma performance levels as being normal. In these cases, these processes create between 6,210 and 66,807 defects per million opportunities (DPMO), while the 6 sigma standard has only 3.4 DPMO which translates to less costs for fixing product defects (Table 1).

Table 1. DPMO and Improvement per Sigma Level

Sigma Level	DPMO	No. of times improvement
1	691,462	
2	308,538	2
3	66,807	5
4	6,210	10
5	233	27
6	3.4	70
7	0.019	179

Source: adapted from Gygi et al. (2005), p. 23

Six Sigma relies on a few methods that have been used for years and have proven their contribution. This methodology discards a lot of the complexity that characterizes TQM. For example, a single expert managed to develop over 400 TQM tools and. Six Sigma takes a few proven methods and trains several in-house technical leaders, known as Six Sigma Black Belts, to a high level of proficiency in the use of these techniques. Some of the methods used by Black Belts are highly advanced such as up-to-date computer technology. But the tools are applied within a simple performance improvement model inspired by Deming's Plan - Do - Check - Act Cycle. This model can be DMAIC, which is used for projects aimed to improve and existing business process, or

DMADV, which is used for projects aimed at creating a new product or process design (Thomsett, 2004). DMAIC are acronyms that stand for Define, Measure, Analyze, Improve and Control and are described briefly as follows:

D*efine* the problem, the customer's needs and/or demands and the project goals.

M*easure* the existing system, certain perimeters of the current process and gather the needed data.

A*nalyze* the system and processes in order to determine ways of eliminating the difference between the current system or process performance and the desired goal.

I*mprove* the current system or process with the help of the gathered data in order to create a new and more efficient process.

C*ontrol* the newly improved process to be sure that it is running in the desired parameters.

Some companies use a ***R****ecognize* phase at the beginning which intends to recognize the right problem that needs to be solved, thus leading to a RDMAIC methodology.

The DMADV methodology is also known as DFSS, or Designed For Six Sigma, and stands for Define, Measure, Analyze, Design and Verify and are described briefly as follows:

D*efine* the goals that are in accordance with the customer's needs and demands and the company's strategy.

M*easure* and detect the aspects that are Critical To Quality (CTQ), the production capability , the risks that it involves and the production quality.

A*nalyze* to create and design alternatives, and after they all have been evaluated, the best one is selected.

D*esign* details, optimize design and plan for design verification (this phase may require simulations).

V*erify* the design, test in to see if all goes according to plan and then hand it over to the owners.

Within the individual phases of DMAIC or DMADV, Six Sigma uses established quality management tools that are also used outside of Six Sigma, such as: 5 Whys, analysis of variance, ANOVA Gaurer R&R, Business Process Mapping, check sheet, control chart, correlation, cost benefit analysis, CTQ tree, design of experiments, failure mode and effects analysis, general linear model, histogram, Pareto analysis or chart, process capability, Quality Function Deployment (QFD), regression analysis, root cause analysis, run charts, and others.

In simple terms, Six Sigma philosophy works as follows:

1. Observe some important aspect of the marketplace or your business.
2. Develop a tentative explanation, or hypothesis, consistent with your observation.
3. Based on your hypothesis, make predictions.
4. Test your predictions by conducting experiments or making further careful observations. Record your observations. Modify your hypothesis based on the new facts. If variations exist, use statistical tools to help you separate signal from noise.
5. Repeat 3 and 4 until there are no discrepancies between the hypothesis and the results from experiments or observations (Pyzdek & Keller, 2009).

One of the key innovations of Six Sigma refers to the "professionalizing" of quality management functions. Before Six Sigma, quality management was assured by a few people on the production floor and statisticians in a quality department. Six Sigma adopts a ranking system similar to some martial arts, that use different belt color to define a hierarchy that passes through all the business functions. Thus, Six Sigma identified several key roles in order to be successfully implemented which are briefly described as follow:

Executive Leadership that is composed of members of the company's top management and the CEO. They have to set up a vision for implementing Six Sigma. They also empower the other project members with the freedom and resources needed to explore new ideas and concepts for breakthrough improvements.

Champions are responsible for the implementation of Six Sigma across the organization, in a integrated manner. They are selected by the Executive Leadership from the company's upper management. Champions also have the responsibility to mentor Black Belts.

Master Black Belts are identified by Champions, and act as in-house trainers on Six Sigma. They devote all their time to Six Sigma.
Black Belts are subordinate to Master Black Belts and must apply Six Sigma methodology to specific projects. They devote all their time Six Sigma. While Champions and Master Black Belts focus on identifying projects for Six Sigma, Black Belts mainly focus on project execution.
Green Belts are employees who, under the guidance of Black Belts, have to implement Six Sigma along with their other job responsibilities.
Some organizations use additional belt colors, depending on its/or the project's size. Employees that have basic training in Six Sigma tools are Yellow Belts, and they usually participate in projects, while White Belts are for those trained in the company in the concepts but are not in the project team.
Pioneers in Six Sigma such as Motorola or General Electric developed certification programs for Six Sigma implementation, verifying individuals knowledge of the Six Sigma methods at the relevant skill level (Green Belts, Black Belts, etc.). This process has grown after the 1990s, when many organizations offered Six Sigma certifications to their employees. Even at this time there are no worldwide agreed standards for certification. Thus, The American Society for Quality has different standards and requirements for certifying that an individual is at a Green Belt level, than the ones that The International Quality Federation has, or Juran Institute, Six Sigma Qualtec, Air Academy Association and many others that provide Six Sigma certification services.

3. SIX SIGMA FOR THE CLOTHING INDUSTRY

We can all agree that perfection in the clothing industry, in many cases, means that the product meets the customer's specifications. For example, manufacturing a size "large" shirt, which has a specification of 42 inches +/- 3/4 inch, does not mean that all of the produced shirts measure exactly 42 inches, but rather that all of these shirts measure between 41 1/4 inches and 42 3/4 inches. A very important concept of Six Sigma is that the output variation is very small. Thus, when size "large" shirts are produced their sizes will be so close to 42 inches that when something doesn't go according to plan, such as bad cutting, sowing or a gauge being misadjusted, the finished shirts are still in the necessary parameters.
Convincing apparel executives to accept Six Sigma process is a difficult task, the latter preferring selling tools and techniques. The only common idea is that every garment can't be manufactured to the perfect specifications. Clothing factories managers are generally amazed by the "True Cost of Quality" in their manufacturing facility. Usually, there are a few hidden costs in overhead that include inspection, sorting, supervisor time, marketing, transport, re-inspection, and cleaning. Thus, any improvement in quality has a positive effect on lowering the total fabric cost, in the reduction of indirect labor, and the improvement of customer satisfaction. Direct labor productivity will usually show a 10-15 percent improvement because the repair time is shorter, imbalances are corrected, and the throughput is higher.
The measurement and analytical processes needed by Six Sigma use tools and charts that are available in many factories already, such as check sheets, histograms, Pareto charts, and scatter diagrams. Using the latter listed, fishbone diagrams (also known as Ishikawa diagram) and flowcharts can be easily drawn by hand.
The analysis and eventually the improvements arise from human interpretation of the data available and a logical thought process. In this phase of the project there are two areas that can be greatly assisted by the complex computer programs given at one time. The first is to determine whether the changes observed are statistically relevant. If it turns out that they are not relevant, unnecessary adjustments avoided. The second one is not very useful for the clothing industry, and refers to the design of experiments capability in order to determine what set of changes will lead to the best result in the end. Given the time for thought and experimentation, experienced and motivated people are the critical resource for analysis and breakthrough improvement (Atwell R, 2005).

In many cases controlling the changes means trying to improve everything that has been measured. While computer software can calculate and monitor the parameters in order to know when a process has a problem, these limits loose most of their value in an environment where human operators are used. Manual calculations, charts and drawings will allow the implementation team to quickly recognize the changes in an average clothing factory.

Taking into account what has been said above, I would like to propose a hypothetical case study on a clothing factory, where Six Sigma methodology and tools will be applied to it.
At the beginning of 2012 an clothing company named S.C. X S.A. noticed a 8% annual customer complaints increase for 2011. We will try to eliminate this problem by making the company more efficient using the Six Sigma DMAIC methodology.
Define: Annual customer complaints increase by 8%
Measure: Major faults that occurred in the final product wore analyzed with the help of the histogram for prioritization.
Defects per unit (DPU) = total defects/total units
Defects per million opportunities (DPMO) = DPU X 1,000,000
Defects% = DPU X 100
Yield% = 100 - Defects%
Process Sigma (or Sigma Level) = NORMSINV(1 - DPU) +1.5
Where NORMSINV is the Excel function for calculating the Sigma Level and 1.5 represents the Sigma shift.
Analyze: The Process Failure Mode Effects Analysis (PFMEA) was used to determine the Risk Priority Number (RPN) value and action was taken accordingly. It is a systemic analysis of potential failure modes aimed at preventing failures or errors.
Using PFMEA implies firstly identifying the potential failure modes, and that determining the actions needed to be taken in order to correct them. After these actions are implemented, the process is evaluated once more in order to see if the new result is acceptable or not.
Improve: The Six Sigma implementation team came up with various improvement suggestions. Some of the most notable ones were:
1. The quality inspector had to participate in a series of training courses regarding quality.
2. A Quality Awareness Program was implemented for checkers and operators.
3. A well defined quality manual was developed for the company.
4. Work instructions wore developed and issued to each department.
5. Quality defects solving teams were created in each department.
As a result to these measures:
1. There has been a significant decrease in defects per million opportunities (DPMO) in all of the company's manufacturing lines.
2. The Process Sigma level increased overall by 31.17%.
3. There has been a 13% increase in sales as opposed to the same period the year before.
4. Thanks to a newly implemented quality checking system and the constant monitoring by the trained quality inspector, a drastic reduction in quality defects level was registered.
5. It can be said for certain that this kind of change can only be noticed after foolproof measures have been adopted to check quality and make workers, checkers and middle management aware of them.
Control: Control chart and plan were created.

4. CONCLUSIONS

Over the years Six Sigma has proven itself to be a powerful and noteworthy management tool with the aim to reduce costs or increase the profit margin of the companies. From my point of view it is a fairly simple tool that can be used to attain financial benefits. Because I come from a region with many clothing factories, I intended through this paper to help them gain competitive advantages, knowing some of the challenges they face in manufacturing clothes. Six Sigma has been validated over and over again by well known companies such as Motorola, General Electric and many more. Due to the specialized belt infrastructure needed to implement Six Sigma, companies with less than 500 employees are less fitted for this methodology, and another reason why I say this is because larger organizations have bigger opportunities for the type of improvements that Six Sigma has to offer. In the clothing industry most of the times defects cannot be repaired, which results in a waste of materials, time, workforce and other indirect costs. In order to prevent such costs, I advise companies in the clothing industry who are eligible to use Six Sigma in order to identify the problems and come up with solutions to solve them, and lower the number of defective products as much as possible. Also, with a low product defect level, factories can count on a bigger and constant good quality output. So Six Sigma can be viewed as a production capability increase tool.

However, I think that any company can gain significant financial benefits from a focused quality program, using the statistical tools that have been available for years. All the companies need is a motivated team of people with a structured process and a set of standards, an expectation of continuous improvement of which they are responsible for. In this manner companies that do not have the potential to create the infrastructure needed for Six Sigma, can still improve the quality of their products and gain a bigger sigma level.

Taking into account the case study's results and all that has been said above, it turns out that the hypothesis at the beginning of the paper was correct. Six Sigma is a fairly simple and strict tool that can be used by companies in the clothing factory either to reduce costs or improve profit margins.

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