THE IMPORTANCE OF GAGE R&R FOR IMPLEMENTING SIX SIGMA PROJECTS IN SMEs

Adina Andreea OHOTĂ
Academy of Economic Studies from Bucharest, România
andreea.ohota@yahoo.com

Vlad IORDACHE
Academy of Economic Studies from Bucharest, România
vlad.jordache@yahoo.com

Abstract

The difference between the economic agents that offer similar products or services is made based on quality. Consumers are too poor to accept poor quality goods. Ant the other external pressures accentuate the importance of quality as competitive advantage, in relation with increasing organization’s performance, mainly in small and medium enterprises sector.

The tailor measures twice and cuts once. Similar, a decision must be assessed and all relevant aspects must be considered before its implementation. This paper aims to present the importance of using an instrument that validates the data set that is the basis of decision making. The case study presented in this article proves also the supplementary benefit of this instrument, meaning the identification of variation causes from the measurement systems, shortening by this the path to process improvement.

Keywords: quality, SME, process improvement, gage R&R.

JEL classification: M11

Introduction

Today, the whole activity of economic agents and consumers is under the sign of crisis and uncertainty. The news received from the external environment is contradictory. If from a political point of view we find out that we are either out of the crisis, or that we are spearing no efforts to surpass and we are reassured by the governing team that what was possible was done and that their efforts were successful, the economic environment presents a different situation.

The business environment is characterized by a high level of uncertainty that is reflected in the way of deploying economic activity. Organizations must adopt the rules of the market game in order to benefit from the offered opportunities and to undertake the existing threats. Worldwide economic organizations are activating under the influence of market and technological changes, dominated by the political economical and social environment (Vlad Iordache, 2010, p. 1).
On the site of the Ministry of External Affairs is stated the policy of Romanian Government with respect to the business environment. This, is written, is centered on the support of private entrepreneurs and on the stimulation of free initiative. Governmental actions seem to be directed towards the consolidation of stable and predictable business environment, towards the elimination of state monopoly concomitant with the privatization of public utilities, the consolidation of free competition, the increase of transparency and the liberalization of work force market. It is also stipulated: “The main areas of action mentioned in the governing program are referring to fiscal relaxation, financial markets, corruption fighting, elimination of administrative barriers, consolidation of business environment, concurrence policy.”

1. SMEs activity at local level

The enterprise is the most spread organizational form that has a special importance because it is the main creator of value added, it offers jobs and of its performance depend economy’s performances and living standard.

The European Commission has established that in the category of micro, small and medium enterprises (SMEs) are included those companies with less than 250 employees, less than 50 million euro in turnover and less than 43 million euro total assets. From this description is very clear, just by simply observing the business environment, that the most part of the economic operators is represented by SMEs. Below is presented the situation of Romania. The statistical data for the year 2009 presented by Romania National Institute of Statistics (INSSE) are reflected.

![Figure 1. The structure of active Romanian economic operators in 2009](image1)

![Figure 2. The structure of active enterprises in 2009, on size classes](image2)

This information made available by Romania National Institute of Statistics practically proves the importance of the SMEs sector in the local economic activity. SMEs “are considered to be the engine of economic growth” through the development and commercialization of innovations (Radas, Boyic, 2009, p.438). Therefore, analyzing these data, and in accordance with Pareto principle, we can state that solving or better said improving the situation of SMEs by addressing some common specific problems, by identifying the vital few causes, we will obtain a significant improvement of the whole economy.
Today, as we already stated, the situation of SMEs is not that good as advertised in the media. The National Council of SMEs makes a quarterly evaluation of the general situation of SMEs in Romania. The most recent evaluation refers to the first half of 2010, and is based on the entrepreneurial index (computed as a weighted average between the index of the business environment, the index for SMEs, and an index reflecting entrepreneurs’ appreciation of their own company). The analyzed results for the given period have underlined an unsatisfactory overall situation of SMEs, with a small improvement with respect to the second half of the previous year. The situation seems to be worst because it can be clearly observed that 2 companies out of 3 had in 2010 weaker results than in the first year of crisis, that can be translated in the idea that SMEs are already struggling to survive in these conditions, and maybe they have already consumed their resources and all precaution measures like costs reduction have no future perspective.

2. SMEs and quality

„Life experience has already proved to everybody that integration in the environment is vital” (Ilinca Hotăran, 2009, p. 216); integration in this context refers to the transformation of companies in flexible systems that are capable to continuously improve. Quality and improvement are “hot spots of the day”. Everybody speaks about quality. Each person seeks the best quality product that satisfies his/her needs, whilst each organization seeks to improve in a continuous way its activity in order to maintain the stakeholders content. “Due to an increasing pace and complexity of business environments, organizations no longer compete on processes but the ability to continually improve processes. (Teece, in Anand et al., 2009, p. 444).

Even if organizations are aware of the importance of quality, as a driving force of excellence and in simple terms of market survival, is observed that they do nothing in this regard. A recent study (Pitic, 2010) has pointed out the fact that the strategic objectives of SMEs are not aligned with this objective of quality and continuous improvement, quality being, as we can say, just a promotional means. These companies are still limited by the traditional theory of costs reduction that do not see how and are not patient enough to make the investments in future that shall bring them the necessary financial benefits. These investments in the future are related to the implementation of some new quality methods, techniques and tools, such as Six Sigma and/or Lean methodology, Balanced Scorecard and QFD tools that accompanied by a total cultural change offer the solution of present problems. Moreover, the continuous improvement literature (Granerud, Rocha, 2011, p.9) sustains that in order to attain superior levels of performance is necessary to have the supplementary managerial support for organizational learning and improvement objectives.

Quality for an SME doesn’t mean the same thing as for a large organization. Why not? Well, key difference is related to size. A large company that offers a variety of products or services and has a multitude of resources (financial liquidities among others) can afford to supply sometimes the customer with a poorer quality and still to remain in business.
During the last years became obvious the idea that customers have come to expect and to accept a poor quality from large corporations, as long as these make it up in some other way. The customers expect to be some defects, and these do not take them by surprise. But as we say, the corporations compensate these situations, whilst small companies cannot. This is the reason why SMEs feel an increased pressure related to the customers’ supplied quality. This means that a similar product or service offered by an SME must have a superior quality to the one offered by a corporation, this being a necessary condition of SME, but in no way a sufficient one.

3. Theoretical aspects of gage R&R in the context of continuous improvement effort

Variability but also the world’s statistical approach have not been debated enough and, in fact, have been even unappreciated (Montgomery, 2010) for a long period of time, being considered that only the physics laws and the economic models represented reality and offered enough data to forecast future events. Later on this conception proved to be wrong, and so appeared the need to understand statistical aspects.

Philip Crosby is the one that sustained and advertised Six Sigma even before it appeared. Even if it sounds weird, this phrase taken to the extreme is logical because in the 1960 he initiated the Zero Defect Movement (ZD Movement). The idea behind this is Crosby’s adversity related to Acceptable Quality Level. This refers to the biggest quantity of defective products from a sample of a certain size that makes the batch being considered at an acceptable level. However, the competition shall “educate” the client and shall establish its values. There is one ideal quality acceptable level, meaning zero defects, all others being compromises based on levels acceptable from an economic, financial and safety point of view. Crosby’s idea was that, as the customer pays for the entire batch as being good, he should also receive a complete batch defect free. His opinion is that the occurrence of defects can be avoided and in order to obtain the goal of zero defects perfect processes must operate.

Today we know that perfection does not exist, and moreover, in our understanding perfection changes because it is a function of our desires; but we know also that we can and we really have to tend to perfection because this is the only solution to remain on the market.

One of the efforts for continuous improvement that tends to perfection due to the target imposed at 3.4 defects at one million opportunities is Six Sigma. Six Sigma is an organizational process that allows companies to improve drastically the profit through structuring and monitoring daily activities in such a way to minimize the losses and resource consumptions, all correlated with the decrease of errors and elimination of quality deficiencies. On the other hand, Six Sigma approach includes, according to Al. Isaic-Maniu and Viorel Gh. Voda (2008) “strategic and operational methods to obtain a degree of excellence in the quality of products and/or services”.

Vol. III nr. 2/2011 33
A recent work named A Framework for Effective Six Sigma Implementation (Jones, Parast, Adams, 2010, p. 415) makes a review of studies and stipulates that “academic research in Six Sigma is lagging behind its practice in the industry”, suggesting thus that the popularity of Six Sigma is won correctly through the efforts of organizations worldwide.

Academic research was accelerated in the last years due to what was happening on the market, the success and visible extraordinary results of Six Sigma. Studies like the ones of Linderman et al. (2003), McAdam and Lafferty (2004), Schroeder et al (2008) were underlining the fact that the successful implementation of Six Sigma cannot be realized without attention at both the process perspective and human component. It is true that the initial studies were concentrating only on the part of techniques, tools and methods, but in the recent years the studies have taken into consideration also the human touch, the contextual and psychological component and the system of rewards and compensation (in Buch & Tolentino, 2006), purpose (in Linderman, Schroeder, & Choo, 2006), organizational context (in Choo, Lindermann, & Schroeder, 2007a) and psychological safety (in Choo, Lindermann, & Schroeder, 2007b).

It is well known that Six Sigma address costs to minimize them and efficiency to increase it, most studies being concentrated on these two aspects; however Six Sigma can be used in other purposes less known, but brought to front by recent studies: to increase profitability (in Sodhi & Sodhi, 2005), to encourage creativity (in Biedrz, 2001), for stimulating organizational learning (in Wiklung and Wiklung, 2002) and for facilitating innovation (in Byrne, Lubowe and Blity, 2007).

Six Sigma success resides in the rigor of discipline, techniques and tool used. Most of them are not new, but part of the statistical and mathematical area and have been promoted due to the remarkable results that can be obtained with their help and the power they have in certain phases. One of these instruments is Gage R&R.

No measurement system is perfect but however we are based on this system to collect the necessary data for the quality control and for monitoring critical process (Minitab tutorial). This is why is important to use a tool that helps at the identification of problems from the measurement system to ensure accuracy of collected data and realization of real improvements.

The name of Gage repeatability and reproducibility comes from the repeatability and reproducibility of the measurement system. This study is a statistic tool that measures the quantity of variation in the measurement system that comes from the measurement devices and from the operators.

When measuring the product of any process two sources of variation are identified the variation of the process itself and the variation of the measurement system. The purpose of conducting an Gage R&R is to be capable to distinguish between the two types of variation, and to reduce the variation of the measurement system if it’s excessive.
Generally a study R&R is realized before it’s being used. We repeat it as many times as we have a new operator or inspector; moreover this is part of the annual training and of the certification process. Also we repeat it annually to be sure that there are no erosions of abilities. It is used as part of the DMAIC process of Six Sigma of any variation project.

The evaluation of measurement accuracy and precision is realized through the determination of two aspects:

- **repeatability** of measurement (the existence of a closeness between a significant number of consecutive measurements of the total result, having the same value of inputs and maintaining the same operating conditions). Figure 3 presents repeatability: 1 measurement system, one operator, repetitive measurements.

![Figure 3. Repeatability](image)

*Source: Adaptation after Scutoski & Sekar*

- **reproducibility** of measurements (the existence of a closeness between repetitive measurements of the results, having the same values of the inputs and maintaining the same operating conditions, for a period of time). Figure 4 presents reproducibility: one measurement system, two operators, repetitive measurements, one part.

![Figure 4. Reproducibility](image)

*Source: Adaptation after Scutoski & Sekar*
Thus, Gage R&R proves if the inconsistencies from the measurements are way too high to be ignored, this leading to some wrong decisions that can affect the entire organization.

As stated above, through Gage R&R are underlined two types of problems:

- an inconsistent measurement tool is used. This problem appears when the same operator uses the same measurement tool to measure the same part, but the results are different. In this case the measurement tool must be recalibrated. Ignoring this cause leads to inaccurate results;

- differences between operators appear. This problem appears when there are differences between the measurements of two different operators; usually new operators must be trained for using the measurement system.

4. Practical aspects of Gage R&R, case study Six Sigma project

The Romanian company ACZ produces and directly commercializes paints and adhesives for internal market. The project with the theme “process preparation for shifting from the sales in kilograms to sales in liters for paints and adhesives” appeared from the costumers need to pay for a volume unit, the same as other suppliers of similar products (meaning the exact quantity written on the label, according to the legislation in force). When choosing the mission statement the team took into consideration that the implementation of recommendations made in the present project should constitute the bases for aligning to market requirements for packing and supplying liquid products like adhesives and paints.

At the initial analysis the team and the black belt have established the approach of this project, the conclusion being that in order to obtain a clear result it must be respected the correspondence o weight-volume according to the density of each packed product and the weighted error at packing to be less than 5%.

According the DMAIC methodology, the process map was elaborated for all the team members to know this project. Then it was elaborated a plan of measurements that include what should be measured, the responsible persons and the completion terms for the data collection. So the team members have reached the conclusion that a Gage R&R is the most appropriate instrument for this case. For this type of analysis where used three operators, each measuring three times each of the 25 cans of paint, randomly extracted from a sample of 200 Kg.

This data have been then analyzed with dedicated software (Minitab), and the results are presented in the figure below.
Figure 5. Gage R&R for the first set of data

From this chart we can observe the following ideas:

- from the overall variation the factor given by repeatability and reproducibility is 11.4% and the variation given by the process producing the measuring values is 88.86%;
- but it is observed that the main part of “Total Gage R&R” is given by repeatability which means that variation is due to human error (reading error and/or absence of mind).

Is commonly accepted that a process can function between the given specification limits with a variation of repeatability a reproducibility less than 10%. The value of 11.4% is quite close to the process functioning limit (of weighting) and so this could function ok (not very good) in these conditions, but due to the fact that repeatability has a quite significant percentage in total variation the team decided that this percentage could be lower if the operator would be trained for the operation of weighting.

In order to observe if this decision had the intended effect the operators that have initially realized the measurements were involved in detailed training with respect to this operation, and afterwards a new set of data was collected.

So it was realized that third set of data* respecting the same initial conditions, it was analyzed with Minitab and the results are presented in figure six. From the third set of data could be drawn the following ideas:

- from the total variation the factor given by repeatability and reproducibility is this time 0.03 %, and the variation given by the process is 99.97%;
- just with training before the measuring operation, the variation given by the repeatability was practically eliminated.
Figure 6. Gage R&R for the third set of data

Note* - with respect to the second set of data all the team members reached the conclusion that these data have been compromised (initial condition from the first set of data have not been respected) and so it was the need to realize the third set of data.

In this phase the variation given by repeatability and reproducibility is practically insignificant, and the only variation that could be reduced is given by the process producing the measuring values. The project team and the sponsor have decided to elaborate the recommendations for this project. So it was proven that Gage R&R was the best choice of the project team because it solved in a very short time the problem.

The recommendations of the team were:

- procurement of an performing electronic weigher set on position;
- periodical verification of the weigher;
- cans tare made at each batch trough weighing a significant sample and then calculating the mean
- only specially trained operators to be used for this operation;
- operators training to be made when weighing each type of product;
- batch density to be determined as exactly and correctly possible (to be collected more samples and to be analyzed as a mean sample);
- and in order to eliminate the variation given by the process producing the measuring values is necessary to dose in an automatically manner the paints (procurement of a paint automated dozer).

This project represented the basis of an another Six Sigma project which was exactly the shift to selling the paints and adhesives in volumetric units, project that brought benefits both for the costumers and the organization, making easier cost management.
Conclusions and recommendations

Each step of this process is subject of variation, but the variation degree that can be tolerated in a process depends on the variation impact on the process and on the customer’s satisfaction. This is normal because excess variation leads to errors, delays, scrap, and rework and in the end at loss of business. When we try to improve the process efficiency, the first objective is usually to reduce the variation.

For the processes that include a high human intervention, a very powerful and relatively easy to use tool is gage R&R. The power of this instrument resides from the differentiation between the variation caused by the human and the variation caused by the process, helping also to concentrate the improvement efforts in the good direction.

The most important lesson that is proved in Six Sigma is that never it must be assumed that a data set is valid. In order to make decisions based on this, it must be proven that the data is accurate and precise. Going even deeper with this idea, in time was proven that the measurement systems tend to degrade. Thus, it is important that they are assessed to validate the offered data.

For the ones that think this instrument is difficult to be used, even if the dedicated softwares are doing everything, it is an alternative of this instrument but also from the statistical area, namely the hypothesis testing. But in this latter case, we must choose between multitudes of such tests, which in the end could require even more knowledge.

It was observed that quality mature organizations tend to skip the gage R&R, having the base of historical data and accumulated experience. It was also proven that this is a backwards step that will make a six sigma project difficult and even fail, despite the impressive efforts of the project team members.

Summarizing the facts, is very important to know that a simple tool, easy to understand and easy to use I vital for the validation of the data set on which decisions are based. Moreover, this tool also helps at the identification of process variation sources, shortening and concentrating in this way the efforts dedicated to the elimination of variation.

Acknowledgements

"This article is a result of the project POSDRU/6/1.5/S/11 „Doctoral Program and PhD Students in the education research and innovation triangle”. This project is co-funded by European Social Fund through The Sectorial Operational Programme for Human Resources Development 2007-2013, coordinated by The Bucharest Academy of Economic Studies."

References


Vlad Iordache, *Managementul calităţii şi diminuarea riscurilor*, Conferința anuală a doctoranzilor în ştiinţe economice ediţia a II-a, Evoluţii şi performanţe în contextual European, 2010


