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**Six-Sigma.
The effects of a disciplined data-driven
approach on HR management in SMEs**

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Quaderno n. 143/ottobre 2019

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Abstract

The aim of the work presented in this paper is to put in evidence the effects of the introduction of Six-Sigma in SMEs, the main changes in HRM it requires, the obstacles and the critical role of the consultant in the various implementation phases. In this exploratory study, the Authors analyse how Six-Sigma, as a disciplined data-driven approach, can improve firm's performances through a change that essentially passes through the redesign of work activities - based on employees' new mind-set and competences - thanks to the use of data produced by the production processes. In order to develop a rich understanding of these Six Sigma effects, two corporations have been selected: one in manufacturing and the other in service, operating in two different industries and in different phases of the implementation.

Keywords: Six-Sigma, process reengineering, data management, decision making, DMAIC, change management

1. Introduction and contextualization of the research

Six Sigma is a disciplined methodology for eliminating defects in the production system as well as a set of management techniques intended to improve business processes by reducing the probability that an error or defect will occur (Schroeder et al., 2008). Based on the data-driven approach, it drives toward six standard deviations between the mean and the nearest specification limit in any process – from manufacturing to transactional and from product to service. Its implementation supports firms in reaching a higher level of performance in terms of productivity (Tjahjono et al., 2010) but also a high level of satisfaction and motivation on the part of all the staff in the workforce. As a matter of fact the application of the methodology leads to the discovery of incorrect working procedures, shows where changes are necessary and where to implement them. The aim is about making the company able to deliver the product or service to an ever more demanding and sophisticated customer with a production cost that has been minimized and the full involvement of the workforce (workers, managers, entrepreneurs) in the decision making process.

This methodology - based on the analysis of the data produced in the execution of production processes (data-driven approach) induces the firm, then its managers and personnel, to become and be constantly aware of how principles act according to a holistic vision. In this sense, data analysis shows where gaps are and in which part of the process it is necessary to promptly intervene through a redesign of the procedures.

Currently, there are many books and articles on Six Sigma written by practitioners and consultants but only few academic articles published in scholarly journals (Linderman et al., 2003, 2006). Reviewing the literature (Tjahjono et al., 2010), our attention has been captured by the fact that many of the definitions are very general and do not provide elements or factors (variables, constructs, concepts) to identify and examine the mutual effects of Six Sigma on

HR management processes (Zu, Fredendall, 2009; Albeanu et al., 2010).

This requires the introduction of new measuring systems and both managers and workers need to become familiar with new tools and practices. As a consequence, new competencies and professions should be needed and jobs should be redesigned: everyone inside the company must be prepared to read, interpret and manage data as an ordinary task.

All these changes, of course, require training addressed to develop employees' competencies in terms of flexibility, ability to adapt and decision-making based on data. The real critical success factor for the company is that the solutions pointed out by Six Sigma has to become the new way of thinking, working and managing both for workers, managers and entrepreneurs.

If these kinds of changes have already being introduced and implemented in big and structured corporations, in SMEs decisions are often made more on the basis of intuition than numbers: in this sense, we argue that the application of Six Sigma should be of great benefit (Antony et al. 2005a).

It is for this reason that in this article we are particularly interested in the adoption of Six Sigma in SMEs (Maneesh et al., 2011) where systems based on data and analytics are just now being evaluated and introduced. As we are convinced that HRs are critical to reach the results the Six Sigma implementation points out, we believe that a study on this is more than ever necessary.

Understanding Six Sigma adoption within the SMEs is considered one line of research to deepen (Lee-Mortimer, 2006). In detail, our research is addressed at analysing the changes occurred with the introduction of Six-Sigma in two SMEs working in two different sectors of activity. The analysis takes into consideration the obstacles and difficulties related to the implementation of Six-Sigma as well as the improvements occurred and proposes a structured and effectively

validated methodology to overcome them. In this respect, the paper analyses the effects of Six Sigma on HR management under different aspects such as job redesign, new professions, impacts on workers motivation in a change management perspective.

The reasons why this contribution can be considered innovative are twofold: on one side, the research is applied to SMEs and not big size and structured companies; on the other, the cases describe two companies that are very different from each other. Six-Sigma is mainly applied to manufacturing companies: in this paper we discuss the application of the methodology not only to a manufacturing company but also to a service one.

In any case, the Authors underline that this is an exploratory study, from which to draw very first indications with respect to the hypotheses.

2. The definition of Six Sigma and its adoption in SMEs

2.1 The definition of Six Sigma

The initial six-step process introduced by Motorola University Design for manufacturing training programme in 1988 (Watson and deYong, 2010) known as Six Sigma is a management practice that, as an extension of total quality management, helps firms to better use data for their decision processes towards higher efficiency, efficacy and flexibility on one side and employees' competences development and higher motivation on the other.

In the literature Six Sigma is defined according to different perspectives. A basic view considers Six Sigma as a set of statistical tools and techniques used for organizations' processes quality improvement as a problem solving method (Goh and Xie, 2004). Achieving a Six Sigma level of quality means having a process that generates outputs with <3.4 defective PPM (parts per million) of non-conforming products.

With a wider perspective Six Sigma is also defined as an analysis methodology based on the scientific method for continuous improvement to reduce process variability and remove waste within the business process (Cardona Mora, 2014).

Other authors (Pepper, Spedding, 2010) propose a definition of Six Sigma as an operational philosophy of management. This view can be related to the fact that Six Sigma principles, in the last two decades, were implemented outside the electronics industries, such as Motorola, and then spread in many other sectors especially in service industries (Delgado, 2014). Supply chains, hospitals, local government and public sectors were interested in the implementation of Six Sigma as a flexible and at the same time disciplined approach used to define and execute projects rigorously, according to a project driven management approach. Following this view Six Sigma is oriented towards customer satisfaction, business improvement to increase quality, speed up the deliveries and reduce costs (Singh, Singh, 2015). It can enhance factual decision-making in companies looking for higher levels of business performance to achieve strategic objectives. Six Sigma is viewed as a more comprehensive management systems.

According to a wider and wider interpretation Six Sigma is pointed out as a business culture. The success of Six Sigma does not rely only on statistical tools and techniques but on the creation of a culture of quality control, productivity enhancement and continuous improvement deeply embedded in every employee (Antony, 2004). This means that the commitment of the top management towards the involvement of the employees must be strong. (Sparrow, Otaye-Ebede, 2014)

Six Sigma is based on the “5M+E Principles” (Measures, Materials, Manpower, Machines, Methods + Environment) and $Y = f(X)$ where Y means Production and X is represented by the 5M+E principles. It is based on the DMAIC methodology applicable in all firm processes to:

- Define the problem and the result of the process (Y)

- Measure the data that describe the situation and start the data collection
- Analyse the causes of the problem with qualitative and statistical systems
- Improve, find the solution and implement it
- Control the processes to search and manage the causes of the variation.

DMAIC can help integrate human aspects, culture change, training and customer focus on one side and process aspects (process stability and capability, variation reduction) on the other. All the DMAIC activities that the methodology requires are staff operations that are expensive and just the implementation of new operating systems based on DMAIC can allow the company to be repaid by cutting wastefulness of resources. Introducing this methodology means adopting a new mind set through new systems based on a constant activities measure, control and improvement (Garza-Reyes et al. 2010)

The role of the Human Resources is essential towards the spreading of a quality culture. McAdam and Laffert (2004) agree that empowerment of people, involvement, motivation, effective communication, reward and recognition systems play a critical role in the success of Six Sigma implementation. Through a transformational leadership employees can be motivated to achieve boundless goals rather than their own short-term interest (Montes and Molina 2006). According to this view Six Sigma can be integrated into the strategy formulation process to gain all the benefits. Providing a high-quality product culture means also to satisfy the customers' requirements strengthening a customer satisfaction culture (Thomas et al. 2009). Customer focus, employee involvement, continuous improvement, transformational leadership and fact-based decision making are pillars of DMAIC methodology that allows to translate the Total Quality Management philosophy into practices (Green 2006, Black and Revere 2006). For the Six

Sigma implementation success IT and state of the art IS infrastructure are a fundamental managerial tool (Han et al 2008).

2.2 The rising importance of Data Culture

The adoption of Six Sigma based on the DMAIC methodology implies the introduction of a structured way of carrying out the processes and their activities. The process results depends on how the problem is defined, measured, analysed and controlled after finding the solution and implement it through continuous improvement. The method is largely based on data collection and on statistical systems to measure and analyse the problem and find the right solution to implement. Controlling the process means to constantly search and manage the causes of the variation through the analysis of data collected.

Data management has a central role and can be considered a critical success factors either of Six Sigma implementation and of process results to boost productivity, efficiency, flexibility and customer satisfaction. From a different point of view data management challenges the organizational culture. It needs to become part of the organizational culture accelerating the application of Six Sigma, making it more powerful and reducing the risk of not achieving the defined objectives.

The adoption of a data culture embedded in the organizational one is central when a company undergoes digital transformation processes with the introduction of data analytics and the use of big data. *“By now, it’s clear the data revolution is changing businesses and industries in profound and unalterable ways”* (Diaz, Rowshankish, Saleh, 2018, pag.1).

Companies are facing the use of data analytics in different ways: some are leading the process, others are more late. Data analytics in general and data management for Six Sigma implementation in particular are now a reality of modern organizational life. A healthy data culture is becoming increasingly important. The DMAIC

methodology can be a first step towards a data culture adoption even in SMEs.

With the DMAIC approach decision-making changes: decision are based on factual data and not on instinct or impressions. This can be a critical success factor, a source of competitive advantage. In fact the fundamental objective in collecting, analysing and deploying data is to make better decisions. This requires the development and implementation of a data culture and it must concern all the company and not a part of it, for example data specialists. The goal is to achieve deep business engagement motivating employees, creating a sense of purpose and a strong problem- solving attitude that supports operations.

In our analysis all these aspects are investigated paying a dedicated attention to the rising of a data culture in the two reported cases.

For the creation of a data culture the commitment of the CEO and the Board is essential. In SMEs, depending on their size, it is crucial the role of the company owner and of managers. The connection that links the different levels of the organization, supporting a data management perspective for decision making and operations can have good results if it is strong and on going, not occasional. All actors need to be focused on the same direction considering a data culture a value that can make the difference and that must be constantly encouraged (Santana Lambert Marzagao, Carvalho, 2016). New roles can be introduced and pilot programs need to be adopted by the business at scale with top management supporting them.

In success cases of SMEs running Six Sigma processes consultants played a central role as facilitator in supporting and spreading the creation of a data culture. Educational sessions at all levels can deepen the understanding of the measuring, analysing and control method applied to business processes. A further understanding for owner and managers of the DMAIC methodology business benefits

comes from the first positive business results and goals achieved. All these aspects make owners encouraging the adoption and spreading of the new data culture. In cases of leading multinational senior management realizes that data is the lifeblood of the organization (Diaz, Rowshankish, Saleh, 2018). Data culture, as a new mind-set, becomes part of the company value system. This doesn't happen overnight. It takes time and commitment that where pursued is a key for success. Considering in particular analytics their adoption is successful when analytics capabilities are embedded in the company core business. Moreover the organizational model is effective when data scientists' work produces a business impact. In the data-analytics debate one central point is how to democratize these capabilities to create innovation and value (Fleming, Fountaine, Henke, Saleh, 2018)

3. Research hypothesis and methodology

In order to develop a rich understanding of these Six Sigma effects, two corporations have been selected: one in manufacturing and the other in service (hereafter referred to as MFG and SERV, respectively). We opted for these two companies with the idea of theoretical sampling (Eisenhardt, 1989) to inform the hypothesis we are developing. They operates in two different industries and one had just started implementing Six Sigma while the other had extensive experience with it. We seek theoretical sampling in theory building rather than the generalizability.

In detail we are interested in testing these hypothesis:

H1: Six Sigma is driving the company through a change in working processes and job contents pushing towards an holistic and systemic view instead of a short term and strict one.

H2: Six Sigma creates new job opportunities and new professionalism inside organizations (i.e. the "improvement team")

H3: After an initial reluctance and resistance, it can have positive impacts on workers motivation

H4: The support of a consultant can be determinant in all the different phases (DMAIC)

To test H1, H2, H3 and H4 the following points were considered and observed.

Fig. 1 – Points observed to test H1

H1	General changes introduced after the introduction of Six-Sigma (in 5Ms+E)
	Changes in the content of the tasks and work processes (“ <i>way of working and managing</i> ”) for workers and managers. Questions related to job re-design
	Changes in the mind-sets
	Changes introduced in the HR leverages (“ <i>Decision-making based on data means transforming human resources management</i> ”): staffing, training, development, career, evaluation processes, compensation
	New practices as a necessity that have been introduced
	New culture and its features

Fig. 2 – Points observed to test H2

H2	New jobs created with the Six-Sigma introduction
	New competencies required (technical, soft, managerial)
	New investments in hardware and software

Fig. 3 – Points observed to test H3

H3	Ways “reluctance”/resistance to change manifested: from the workers’ /entrepreneurs’/ managers’ side
	Once “fully operational” effects on the motivation: from the workers’ /entrepreneurs’/ managers’ side
	Obstacles faced during the different phases
	Positive impacts observed from the different categories of employees, managers, entrepreneurs
	Positive impacts on working processes and on business performances

Fig. 4 – Points observed to test H4

H4	The role of the consultant in the different phases previously described: in the analysis of the actual situation, in the phase of proposal, in the implementation,
	Main difficulties faced by the consultant
	How the entrepreneurs, managers and HR specialists confronted with the consultant

Data collection has been possible through direct and concrete observation of the changes happened in two SMEs in different moments deemed as critical:

- before the implementation of Six-Sigma
- during the proposal of the adoption
- during the implementation
- after implementation

Great collaboration and support provided by the companies during the research has guaranteed full observation of the changes intervened and a structured and reliable data collection.

4. The Service and Manufacturing Company: two cases

This research relies on two different cases, one from the manufacturing and the other from the service sector. Both of the companies are SMEs and this represents one of the distinctive traits of the study. The manufacturing one has been founded at the beginning of the '70s and it can be considered as world leader in the sectors of electrical resistances and insulating material. The service company produces only for the Italian market. Its true value is in the people of the technical office in terms of speed and competence.

In the following paragraphs we will give a brief overview of the two companies, then we will analyse the main changes introduced, the new skills and professionalism required, the main obstacles

encountered in the implementation and finally the crucial role of the consultant in assisting the company in the process of gradual change.

4.1 The Service Company

The service company (herein SERV) is an Italian companies that print cardboard packaging, providing design and production of punches. It is in a market where skills and speed of service are more important than price. Poorly designed or late dies can generate very expensive downtime or thousands of non-compliant parts. SERV has completely customized products that are replicated only in the event of breakage or consumption of the already planned system.

With about 40 employees it has a turnover of 8 million Euros and it produces only for the Italian market. The company has easily purchased machinery as the true value is in the people of the technical office in terms of speed and competence: sudden work peaks create difficulties in managing product design. In particular, delays and non-compliant projects are generated. Six Sigma was applied to speed up and eliminate errors in the design phase.

The main figures involved in the different phases (following the DMAIC methodologies) were the entrepreneur and the responsible for the technical office for a one year and 3 months period of time: one month for the Definition, two months for Measuring, one week for Analysing, one year for Improving. At the same time the Control phase was started.

Concerning the new measuring systems the measurement of design time and non-compliance was introduced. The main difficulties faced by SERV were resistance to change of operators and skills that need to be filled. The introduction of Six Sigma has allowed the growth of the skills of the designers and the improvement of customer service. The results are improving and are linked to the long planned training phase.

The use of statistical data has allowed the creation of objective data that have stimulated employees to personal improvement in specific

areas to improve the management of the client and its changing requests.

4.1.1 Changes introduced

In order to analyse the main changes introduced with the adoption of Six Sigma we noticed that SERV has introduced a training plan that has allowed resources to become interchangeable. Some poor performing PCs have been changed. A time-based digital system has been introduced.

Following the adoption of Six Sigma, the contents of the tasks, work processes and management methods have changed. The types of projects assigned to designers have been expanded following the FIFO approach (First in First Out) and while before the subdivision of jobs was based on the skills recognized by the manager.

The division of works by expertise has been abandoned: now managers devote more attention to mapping the skills of designers and creating growth paths. This is a major change with effects on job redesign. The new redistribution of work foresees that the first free designer will take care of the first incoming project arrived in the queue. This has allowed the abandonment of planning by freeing the manager from an onerous and continuous commitment. This is a new practice that has been introduced together with a new culture.

The new culture pushes in the direction of creating people capable of managing any type of project. The new performance measurement method allows constant monitoring of resources and potential improvements. In the company, a new mind-set has been created with greater attention to the time factor and an understanding of the importance of flexibility.

According to a general perspective we can say that introducing decision-making based on data means transforming human resources management. In the recruiting phase the new entries must have a good flexibility. Training is important to support change. In-house

training sessions were introduced to fill existing gaps. On the carrier side, once the training phase is over, the manager can devote time to research and development and to professional growth. As regards performance evaluation processes, after the introduction of Six Sigma the performance measurement is used in individual meetings and is an integral part of the objectives. The salary system has also been modified with the variable part partly linked to performance.

4.1.2 New jobs and professionalism

With the introduction of Six Sigma new jobs and professionalism were created. In particular, the figure of manager of the system for the balancing of time (a timing system) and data analysis was introduced.

The focus is on new technical competences so that all the designers are able to meet every request from customers. These new competences include the use of basic statistical tools and the ability to read control cards generated by software. On the soft skills side change management competences are central. On the managerial side human resources management becomes central in the technical office.

4.1.3 Main resistances

The introduction of Six Sigma has produced forms of resistance to change at the level of designers, owner and managers. For the designers the resistance to change has manifested itself as the will to continue working in the known. The owner showed little willingness to give space to training thinking it was just a problem of people's willpower. Managers have shown little trust in people and their growth potential. They also feared the increase of non-compliant in production.

Once fully operational, a positive impact on motivation has been created:

- designers showed a greater sense of belonging and greater motivation;

- the owner's estimate for people increased;
- managers had a reduction in planning stress.

A general positive impact has been found through the reduction of queues and a better management of peak workloads.

4.1.4 The role of the consultant

The consultant team played a central and essential role in getting the project achieving the objectives desired from efficiency, efficacy and customer satisfaction point of view. The Six Sigma team consisted of both internal and external resources.

In the first phase the consultant acted as a support thanks to knowledge and competence. The team created a measurement system fitting the specific characteristics of the service firm in its technical office. As a second step the team started to analyse the data collected. Starting the project of renewal through Six Sigma adoption the company faced an important change effort. The consultant role was central in convincing the owner, the managers and the technicians to afford the effort needed to achieve the planned results. In particular during the different phases of the project the consultant was a time keeper especially when, due to peak work, the change process was interrupted and put aside.

The main problems the consultant faced concerned the low managerial culture and the lack of a data culture. Data and statistical methods were ignored and had very low consideration on the part of the company. The company owner was also in charge of the human resource management. At the beginning he had little faith in the project and in its phases. Trusting the consultant led to a professional growth in terms of human resources management

4.2 The manufacturing company

The manufacturing company (herein MFG) we decided to analyse for the purposes of this paper produces 6000 electrical resistances and insulating material per day on a dedicated line. It works mainly on behalf of multinational corporations that produce hair dryers and

hair straighteners. The environment in which it operates is highly competitive (in terms of price) with lots of competitors from the Far East: consequently, it's only the high quality of the products that permits to get to the customer with a higher price than that practiced by the Asian competition.

With about 60 employees and more than 170 *ad interim* personnel working on the production lines, MFG has a turnover of 40 million Euros and a level of internationalization close to 90%. MFG is equipped with machinery specifically studied for the products and the invested capital is not out of reach. Factors that distinguish the company are the ability to design the product, to create efficient lines and have proper suppliers.

Six-Sigma has been applied for two main reasons: the request coming from the multinational main customer; the request coming from the top management to lower number of “products not compliant” arousing a cost increase and the risk of delay in the deliveries.

4.2.1 Changes introduced

Obviously the introduction of this methodology had a significant impact in terms of change that involved main figures and departments in the different phases. The Quality Department, the Production Responsible and the line controllers have been involved for a period of 8 months. Following the DMAIC approach:

- 1 month for the Definition;
- 2 months for Measuring;
- 1 month for Analyzing;
- 2 months for Improving;
- 1 month for Controlling.

The biggest change introduced concerned the measuring systems and, in particular, lots of work has been done on the measuring

system proved to be inaccurate by the use of the MSA statistical method.

To bypass this criticality, a visual system for “non compliant” accompanied by a document of control for the final test phase have been implemented. Once the first difficulties in the interpretation of data deriving from the processes have been overcome, Six Sigma permitted a decrease in “not compliant” (NC) products and an increase in line personnel competencies with results immediately perceived after the Improving phase (Burke et al., 1995). Data have shown correct standard and allowed employees to be part of a production line with the goal to create efficiency more than flexibility.

As a consequence, the two production lines dedicated to the main customer have been re-designed with the aim to reduce the waste deriving from unproductive handling or personnel movements. Nevertheless, to date the productive system is not optimized yet and still consistent - even if considerably reduced - the percentage of waste (from 2,99% to 0,38%).

MFG has to work on the organization of the registration of the NC pieces and on the HR training in this sense: on a daily base, operators position NCs in bags sign with the machine ID number and workers dedicated to Quality Control (QC) check NC pieces and insert data in a file uploaded in a minitab. Each operator is trained in a punctual way: it becomes necessary to invest on the use of statistics for the analysis of collected data and the development of skills related to decision-making (for the evaluation of the NC pieces).

From a technical point of view, machinery has been optimized through the identification of a DOE (Design of Experiment) with the right setting and standardizing calibrations (in the past left to operators' sensitivity/perception).

4.2.2 New jobs and professionalism

Actually measuring activities have been introduced with the aim to provide workers with a database useful for the identification of potential arising problems. At the same time, managers are invited to create data supporting criticalities and not to limit themselves on simple opinions. New procedure for waste management and reporting of causes have been created together with problem solving sessions aimed at the identification of potential organizational improvements.

In this sense, Six Sigma allows the personnel to understand how data can drive through the identification of the permanent solution. Resistance to change was therefore cut down in front of objective data. The mind set of the employees has dramatically changed in favour of the diffusion of the “kaizen” philosophy, alibi reduction and an active participation to the problem solving sessions.

Major changes have been introduced in the various HR leverages:

- employees with statistical competencies have been introduced in the Quality Functional Unit
- new and specific training sessions have been defined for each role
- statistical tools (control charts) - able to capture performance trends - have been introduced for the evaluation of each employee.

At the same time, new job and professionalism have been developed: an example can be the “Six Sigma team” created to control the measuring system for the statistical data analysis, the implementation of the new projects of improvement and the stabilisation of the new processes. It is evident that for team members statistical skills are required as well as the ability to work in team and manage projects.

4.2.3 Main resistances

In the early stages of implementation the most widespread sentiment was fear both from the point of view of the workers and the

entrepreneur: the main concerns for the employees were about the evaluation process while for the entrepreneur the risk to have no return from investment in terms of human resources involved. In this sense the entrepreneur put pressure on the team trying to have feedback before time.

Once fully operational a positive impact has been created on the motivation both of the worker who has noticed greater trust in the quality department and in the company and of the entrepreneur who has seen latent problems finally solved. Even managers have found a positive impact on motivation thanks to the satisfaction of having learned a new methodology and having obtained an objective result. This positive motivational impact has been objectively identified because the Quality Department, previously not appreciated by the Production, is now often required, the staff in the meetings with the HR expresses satisfaction and a widespread growth in mapping skills is evident.

4.2.4 The role of the consultant

The role of the consultant has been central in all the phases previously described. The consultant conducted the analysis of the situation, performed the training, introduced the measurement and mapping systems. Moreover s/he helped to have statistical certainty of the problem and in this sense pushed to the search for effective organizational and technical solutions. In the implementation phase s/he helped to manage projects in terms of deadlines, supported the team in moments of difficulty of communication and relationship with the operatives.

The main difficulties encountered by the consultant were related to obtaining a real commitment to improvement activities, often delayed to make room for routine and customers. Showing a better future and motivating the efforts of the moment were psychological aspects that made the difference.

Regarding the way the consultant confronted with the company HR, in this case s/he was decisive for the creation of the Six sigma team and for the resolution of problems related to the workforce (training plans).

5. Discussion and conclusion

Nowadays, with the new automation wave (i.e. Industry 4.0) firms produce a big amount of data, not all of them are helpful or needed. As a practical implication, Six Sigma shows the way towards a correct use of the data the firm produces in its processes. First results of the analysis highlight the central and critical role of HR management on two sides mutually influencing: the introduction of a new culture and mind-set and the redesign of the way of working.

The reasons why this contribution can be considered innovative are twofold: on one side, the research is applied to SMEs (and not big size and structured companies); on the other, of the two cases presented one is related to a service industry (Six-Sigma is mainly applied to manufacturing companies).

As emerged by the literature contributes Six Sigma has become part of the wide management system overcoming a more technical perspectives. From being considered just as tools and techniques the perspective has changed with Six Sigma integrated in companies core business, towards a strategic adoption. DMAIC methodology, as a disciplined data-driven approach, has shown all its efficacy in supporting fact-based decision making with benefits and positive impacts on customer focus, employee involvement, continuous improvement and transformational leadership. Integrating DMAIC in Total Quality Management allowed the translation of its philosophy into practice.

Starting from the hypothesis of our framework the main findings of our analysis concern changes, obstacles and facilitators to overcome resistances in the two cases we have analysed. Overall the critical success factor the analysis points out is the crucial role of personnel

management (Manville et al., 2012). Change management activities are developed not only through investments in new equipment but especially for new work procedures and personnel competencies that have required training to acquire an attitude in favour of flexibility and ability to adapt. This appears as a common traits in both the cases considered.

Decision-making based on data has meant transforming human resources management. Current activities and processes have been redesigned considering the results emerged by the application of the “5M+E principles”. The Six Sigma introduction has finally produced changes in the business culture achieving the aim to create a culture of quality control, waste and non-compliant reduction, productivity enhancement speeding up the technical and production processes and continuous improvement.

Two aspects appear to be central for the achievement of the desired objects: on one side the introduction of a project driven management approach as a new way of working executing projects rigorously. On the other employees, managers and the owner himself have been educated to a new culture for data management to support decision-making and processes improvements.

In the service company the introduction of Six Sigma has allowed the growth of the skills of the designers speeding their output with a great improvement of customer service certified by a constant monitoring and controlling of data. In the manufacturing company the scarce attitude towards data management represented the utmost obstacle. The main problem was the high rate of non-compliant. The introduction of Six Sigma permitted their reduction and an increase in line personnel competences with results immediately perceived after the Improve phase.

In both cases, resistance to change was cut down in front of objective data. The mind-set of managers and employees has dramatically changed in favour of the diffusion of the “kaizen” philosophy, alibi

reduction and active participation to the problem solving sessions. New jobs and professionalism have been created where statistical skills are required as well as the ability to work in team and manage projects.

The analysis of the two cases highlights a general increase of motivation, engagement, satisfaction and trust at all levels for employees, managers and owners. In both companies the owners started to trust the project after the first results achieved and their commitment and support have grown with positive effects on the whole project.

The role of the consultants (or consultant team) has been central and critical in all the phases of the DMIAC methodology adoption. They pushed towards the search of effective organizational and technical solutions and constantly confronted with HR. They maintained the focus on the project and on changes introduced with continuity, in terms of deadlines and obstacles to overcome.

Basically they lead the project through a transformational leadership showing a better future and motivating the efforts of the moment. These psychological aspects have demonstrated to help to make the difference.

6. Limitations and further research

This research has investigated the impacts of Six Sigma on two companies (MFG and SERV) highlighting some points of convergence even if they are at different stages of implementation. Based on case studies and not on evidence supported by large numbers, the research is not exhaustive, but aims to highlight the crucial role of human resources for the success of the implementation process in its enormous complexity. Since this area of research needs to be explored from an academic point of view, the research aims to follow up the analysis conducted through the identification of other cases to support the evidence already emerging.

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