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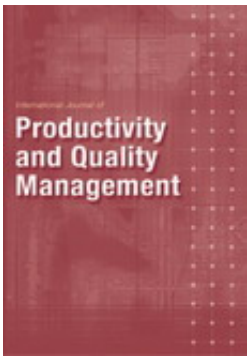

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Improving productivity in SMEs by the implementation of Six Sigma: human resource management implications

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Improving productivity in SMEs by the implementation of Six Sigma: human resource management implications

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Abstract: This paper analyses the implications that Six Sigma can induce in the management of human resources and in the quality of work organisation in SMEs, a field of investigation not yet adequately explored by the scientific literature. The case of two SMEs (a manufacturing and a service company) engaged in different phases of Six Sigma application and operating in different industries is reported. After initial reluctance and resistance, Six Sigma stimulated the creation of a culture of continuous HR motivation and accretion.

Keywords: Six Sigma; data culture; DMAIC; change management; quality management; motivation; decision-making; HR.

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1 Introduction

Six Sigma is a disciplined methodology for eliminating defects in the production system and is 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 towards six standard deviations between the mean and the nearest specification limit in any process, from manufacturing to transactional and from product to service.

As a matter of fact, the application of Six Sigma leads to the discovery of incorrect working procedures shows where changes are necessary and where to implement them. The aim is to make the company able to deliver the product or service to an ever more demanding and sophisticated customer with a production cost that has been minimised and with the full involvement of the workforce (workers, managers, entrepreneurs) in the decision-making process (Psarommatis et al., 2021; Bidikar et al., 2022; Yadav et al., 2022). Based on the analysis of the data produced in the execution of production processes (data-driven approach) Six Sigma induces the firm, its managers and personnel to become constantly aware of how principles act according to a holistic vision. In this sense, data analysis shows where gaps exist and in which part of the process it is necessary to intervene promptly through a redesign of procedures (Gastelum-Acosta et al., 2022; Pandey et al., 2022). Its implementation supports firms in reaching a higher level of performance in terms of quality and productivity (Panayiotou et al., 2021) through the deployment of the DMAIC methodology: define the problem and the result of the process; measure the data that describe the situation and start data collection; Analyse the causes of the problem using qualitative and statistical systems; improve, by finding and implementing the solution; and control the processes to search for and manage the causes of variation.

It is obvious to think that the adoption of Six Sigma based on the DMAIC methodology in SMEs (Soundararajan and Reddy, 2020) implies the introduction of a structured way of carrying out processes and activities, changing job contents and an orientation to a data culture which are not common practices for that organisational dimension (Rodriguez et al., 2022; Ali et al., 2021; Brun, 2011; Deeb et al., 2018; Maneesh et al., 2011; Panayiotou et al., 2021). Resistance to culture change (Yadav et al., 2018), lack of employee involvement (Albliwi et al., 2014), poor estimation of implementation cost (Singh et al., 2019), lack of training and education (Singh and Rathi, 2019) and poor organisational capability (Sreedharan et al., 2019) are some of the barriers that SMEs face if they wish to implement Six Sigma and for which they do not always have dedicated internal resources and skills. It is for this reason that often the help of an external consultant to support the management can be a stimulus and help.

Understanding the adoption of Six Sigma within SMEs is considered one line of research to explore (Sodhi, 2021). In detail, our research was addressed at analysing the changes occurring with the introduction of Six Sigma in two SMEs working in two different activity sectors. The analysis took into consideration the obstacles and difficulties related to the implementation of Six Sigma as well as the improvements seen. In this respect, the paper analyses the effects of Six Sigma under different aspects of HR management, such as job redesign, new professions, impacts on worker motivation and changes in management perspective.

2 Addressing the issue: the adoption of Six Sigma in SMEs

Despite its growing application in the business environment, there are many books and articles on Six Sigma written by practitioners and consultants, but modest attention has been paid in the scientific literature (Patel and Patel, 2021; Puram and Gurumurthy, 2021; Sordan et al., 2020; Singh and Singh, 2020; Singh and Rathi, 2019).

A systematic literature review using Scopus showed that only 206 papers resulted from searching Six Sigma and SME within keywords, titles and abstract, which boiled down to 86 papers if Six Sigma were searched within keywords, titles and abstract and SME within titles. The most interesting discovery was that only ten papers (the last of which was published in 2018) resulted by searching Six Sigma, SME and HR within keywords, titles and abstract. If we limited ourselves to a search on titles, no paper with HR, SMEs and Six Sigma had ever been published.

It is for this reason that in this article we are particularly interested to investigate the adoption of Six Sigma by SMEs (Maneesh et al., 2011; Ali et al., 2021) and, as we are convinced that HRs are critical in achieving results (Stone and Deadrick, 2015; De Koeijer et al., 2014; Albeanu and Hunter, 2010; Zu and Fredendall, 2009), we believe that a study on this is more than ever necessary.

We argue that Six Sigma requires the adoption and implementation of organisational changes in working processes and professional roles. In this respect, Six Sigma drives SMEs through changes in working processes and job contents, pushing the adoption of a long-term holistic and systemic vision of the company rather than a fragmented and short-term one (Albenau and Hunter, 2010; Brun, 2011; Deeb et al., 2018). According to this view, Six Sigma can be integrated into the formulation of strategy process to gain all the benefits available. Providing a high-quality product culture means also satisfying the customers' requirements and 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 allow the translation of the total quality management philosophy into practice (De Oliveira et al., 2021; Al-Atiyat et al., 2021).

Gutiérrez et al. (2012) suggest that Six Sigma should be studied under the aspect of cultural change by considering the effect of the knowledge generated in the implementation of a Six Sigma project and of the employee's mindset, which should be open to accepting changes in the process and trained in different working procedures. In this respect, employees play a fundamental role, as with the adoption of Six Sigma they can be motivated to achieve boundless goals rather than their own short-term interests (Montes and Molina, 2006). It is suggested this aspect is a key element in the success of Six Sigma projects from a perspective of continuous learning and adopting a problem-solving approach and competence (Pereira et al., 2021).

Relying on DMAIC, Six Sigma can help to integrate human aspects, culture change, training and customer focus on one side and process aspects (process stability and capability, variation reduction) on the other (Tiwari et al., 2022). Introducing this methodology means adopting a new mindset through new systems based on constant measurement, control and improvement.

Since the change in the company – especially in an SME – inevitably encounters delays and resistance (Panayiotou et al., 2021) the support of a consultant – acting as facilitator – can be a determinant in all the different DMAIC phases.

Following this overview, with a greater level of analysis and detail with respect to that discussed above, we were interested in verifying the following hypotheses supported by the related literature review:

H1 Six Sigma drives SMEs through changes in working processes and job contents, pushing the adoption of a long-term holistic and systemic vision of the company rather than a fragmented and short-term one.

To test H1, these points (Table 1) were observed:

Table 1 Points observed to test H1

H1	General changes introduced after the introduction of Six Sigma
	Changes in the content of the tasks and work processes ('way of working and managing') for workers and managers
	Changes in mindsets
	Changes introduced in the HR leverages ('decision-making based on data means transforming human resources management'): staffing, training, development, careers, evaluation processes, compensation
	New practices
	New culture and its features

Concerning the changes in working processes and job contents, the adoption of Six Sigma requires the introduction of new roles and pilot programs to be adopted at scale with the support of top management. Following Zu et al. (2008) good management of a Six Sigma project impacts on the role structure with the creation of different professional figures that are introduced for the deployment of the program. For example, companies create improvement teams and the roles of 'belts': experts in continuous improvement who will conduct the project. In small companies this role can be played by external resources specialised in managing Six Sigma methods, procedures and projects (Cho et al., 2011).

Moreover, Santana et al. (2016) argue that project performance depends not only on the correct implementation of the Six Sigma method but also on project management and project manager competencies. The implementation of a Six Sigma project needs a wider consideration of elements, extending to the project management literature. In fact, as for other major managerial innovations, Six Sigma also becomes 'critical to the survival of organisations while relying on project management and change management' [Hornstein, (2015), p.294].

In large companies the evaluation looks at the performance of single projects in a framework of the management of a project portfolio. We were interested in the factors critical for the success of Six Sigma in SMEs, where a single project can represent the core activities of the company. On the good performance of the project can depend the survival of the company itself. From this point of view and for this reason the role of the project manager in conducting the programme is very important (Brun, 2011).

In this regard we were interested in verifying the second hypothesis:

H2 Six Sigma creates new job opportunities and new professionalism inside SMEs.

To test H2, these points (Table 2) were kept under observation:

Table 2 Points observed to test H2

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

The success of Six Sigma does not rely only on statistical tools and techniques but on the creation of a culture of quality control (QC), productivity enhancement and continuous improvement deeply embedded in every employee (McAdam and Laffert, 2004). Like any change, the introduction of Six Sigma is not immediate but must be gradual and supported. In SMEs, depending on their size, the role of managers and the company owner is crucial (Alnadi and McLaughlin, 2021). This means that the sponsorship of the top management in the involvement of employees must be constant and not ephemeral or extemporaneous (Sparrow and Otaye-Ebede, 2014; Singh and Singh, 2020). In this sense, the connections linking the different levels of the organisation, supporting a data-management perspective for decision-making and operations, can have good results if they are strong and ongoing rather than occasional.

All actors need to be focused in the same direction and considering data culture to be a value that can make the difference and that must be constantly encouraged (Santana Lambert Marzagão and Carvalho, 2016; Singh and Rathi, 2021; Loh et al., 2019). Managers and company owners can support Six Sigma operations by giving recognition and positive reinforcement to employees who provide improvement ideas and participate actively in the realisation of process enhancements (Poksinska et al., 2013): that recognition can have many forms and attributes, such as encouragement, emotional rewards and attention and acknowledgement (Aij and Teunissen, 2017).

As the level of Six Sigma advances, employees become empowered and more involved in decision-making (Poksinska et al., 2013). Managers should encourage employees to provide improvement ideas, and employees then have the freedom to make decisions and take suitable actions to realise those intended improvements (Aij et al., 2015; Maijala et al., 2018).

The third hypothesis to be verified is therefore:

H3 Also in SMEs, after initial reluctance and resistance, Six Sigma stimulates the creation of a culture of continuous motivation, empowerment and accretion.

To test H3, these points (Table 3) were analysed:

Table 3 Points observed to test H3

H3	The ways reluctance/resistance to change are manifested, from the workers'/entrepreneurs'/managers' sides
	Effects on motivation once 'fully operational', from the workers'/entrepreneurs'/managers' sides
	Obstacles faced during the different phases
	Positive impacts observed in the different categories: employees, managers and entrepreneurs
	Positive impacts on working processes and business performance

In small businesses, given the lack of a data culture, one of the critical factors in the success of Six Sigma implementation can be represented by the active presence of a

consultant. In cases of SMEs successfully running Six Sigma processes, consultants played a central role as facilitators in supporting and spreading the creation of a data culture, acting also as trainers as well as consultants. Educational sessions at all levels can deepen the understanding of the measuring, analysing and control applied to business processes (Deeb et al., 2018).

The role of facilitator relies on the assumption that the consultant knows how to act in the direction 'to make easy' or 'ease' a process. What a facilitator does is to plan, guide and manage a group of individuals to ensure that the group's objectives are met effectively, with clear thinking, good participation and full buy-in from everyone involved.

In this regard, the fourth hypothesis to be verified is reported:

H4 The support of a consultant – acting as facilitator – can be determinant in all the different DMAIC phases.

To test H4 the following points (Table 4) were considered and observed:

Table 4 Points observed to test H4

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

To develop a deep understanding of the Six Sigma organisational effects, two companies were selected one in manufacturing and the other in the service sector (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 were testing.

3 Methodology

Given the modest number of studies on the subject, we were interested in theoretical sampling (Eisenhardt, 1989). It is for this reason that we chose two SMEs operating in different industries and engaged in different phases of Six Sigma application.

The methodology we applied to test our hypothesis followed techniques of data acquisition based on documents, interviews and discussions with the company staff and the companies' Six Sigma project leaders. Our data collection followed the DMAIC method itself. It was easy to interact with company staff already used to this method because of the Six Sigma projects they had implemented. The project leaders showed us documents in the define phase where the personnel improvement objectives for performance and motivation were illustrated. According to the following measure phase we had access to documents on historical data that during the Six Sigma project had helped the company to understand the initial human resources stage. The companies showed us the data that they collected through the Six Sigma project to evaluate hard personnel skills and map their competencies. In these documents each skill received percentage values for each employee. We also accessed data on employee motivation levels collected through structured questionnaires and translated into motivation indicators.

Thanks to these two phases the companies could start the analysis phase through which it was possible to evaluate problems and the activities necessary to address them. We discussed with the Six Sigma project leaders these data and acquired them for our analysis. The project leaders showed us the work surface of the improve phase. They used the plan to take actions to improve employees' competencies and the companies' organisation. With data collected in the Control phase we could detect whether the actions taken had objectively improved the companies'human resources.

We decided to focus our attention on two companies of small or medium size, one belonging to the service sector and the other to manufacturing, with the purpose of analysing similarities and differences. To select the companies, several factors were considered: the cuscriterion was that the two companies had recently completed a re-organisation process with similar start and end points; the two companies could then focus on a specific factor change: the results of the application of Six Sigma on HR. Moreover, the two companies had in common the fact that data were not used:

- to evaluate the personnel (subjective evaluations on performance were customary)
- to formulate strategies (these were established by the top management based on perceptions, historical trends and other factors)
- to share trends (corporate and functional).

In general, neither the staff nor the entrepreneurial group were satisfied with the current work organisations.

Data collection was made possible through direct and concrete observation of the changes occurring in different critical periods:

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

Great collaboration and support by the companies during this research guaranteed full observation of the changes introduced and structured and reliable data collection.

To analyse the two companies and test the hypotheses we followed a pre-defined list of questions to interview the employers, the Six Sigma project leaders and the consultants involved in the project. At first, we focused on the strategic and critical success factors that allowed the company to compete at high levels in their markets. Then we identified the main difficulties that each company was facing and that the adoption of Six Sigma allowed them to overcome. Given that the Six Sigma methodology centres on statistical data, we tried to understand how these procedures could be applied to HR and how personnel resistance to change was overcome. We asked the companies to analyse the main changes and new practices introduced and the main effects seen with the adoption of Six Sigma. We were interested in the companies' culture changes that after the adoption of Six Sigma would have been largely based on data processing with new systems of performance management and a new personnel mindset. Through the interviews we also investigated the employers' and managers' role and their decision-making processes for the changes that they would have introduced. Our questions and requests for documents were aimed giving answers to our hypotheses. We

used them to analyse the objectives, effects, changes, actions and implications for HR of the adoption of Six Sigma in the two companies. Our aim was to highlight how the project had transformed their management and work organisation with the help of statistics and data applied to everyday work.

4 The service and manufacturing companies: two cases

As described in the methodology, this research relied on two different cases: one from manufacturing and the other from the service sector. Both companies were SMEs, and this represents one of the distinctive traits of the study. The manufacturing company was founded at the beginning of the 1970s and can be considered as world leader in the sectors of electrical resistance and insulating materials. The service company produces only for the Italian market, and its true value is rooted in the speed and competence of the technical office's personnel.

In the following paragraphs we will give a brief overview of the two companies, then we will test the hypotheses, analysing 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 companies in the process of gradual change.

4.1 The service company

The service company (herein SERV) is an Italian company that prints cardboard packaging, providing the 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 customised 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 €8million and produces only for the Italian market. The company uses easily purchased machinery, as the true value is in the people in 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 those responsible for the technical office over a period of one year and three months: one month for definition, two months for measuring, one week for analysing and one year for improving. The control phase was started at the same time.

Concerning the new measuring systems, measurement of design time and non-compliance was introduced. The main difficulties faced by SERV were resistance to change by operators and skills that needed to be filled. The introduction of Six Sigma allowed the development of the skills of the designers and improvements in customer service. The results are in 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, improving the management of clients and their changing requests.

4.1.1 Changes introduced

To analyse the main changes introduced with the adoption of Six Sigma we noticed that SERV had introduced a training plan that allowed resources to become interchangeable. Some poorly performing computers had been changed. A time-based digital system had 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 to follow the first in, first out (FIFO) approach, while previously the subdivision of jobs had been based on skills recognised 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 means that the first free designer will take care of the first incoming project in the queue. This has allowed the abandonment of planning by freeing the manager from this 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 mindset 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 HR management. In the recruiting phase the new entries must show good flexibility. Training is important in supporting change. In-house training sessions have been introduced to fill existing gaps. On the career 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 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 linked partly 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 the system manager for balancing time (a timing system) and data analysis was introduced.

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

4.1.3 Main resistances

The introduction of Six Sigma produced forms of resistance to change at the level of designer, owner and manager. For the designers the resistance to change manifested itself as the wish 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

showed little trust in people and their growth potential. They also feared an increase in non-compliance in production.

Once fully operational, a positive impact on motivation has been created, as designers showed a greater sense of belonging and greater motivation, an increase was detected in the entrepreneur's esteem for the staff, and managers enjoyed a reduction in planning stress.

A general positive impact was found through the reduction of queues and 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 to achieve the desired objectives in terms of efficiency, efficacy and customer satisfaction. The Six Sigma team consisted of both internal and external resources.

In the first phase the consultant acted as a support thanks to their knowledge and competence. The team created a measurement system that fitted 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 the adoption of Six Sigma the company faced an important effort towards change. The consultant's role was central in convincing the owner, managers and technicians to afford the effort needed to achieve the planned results. In particular, during the different phases of the project the consultant was a timekeeper, especially when, due to peak work, the process of change was interrupted and put aside.

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

4.2 The manufacturing company

The manufacturing company (herein MFG) that we decided to analyse for the purposes of this paper produces 6,000 electrical resistances and insulating materials 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 many competitors from the Far East; consequently, it is only the high quality of its products that permits it to supply the customer at higher prices than those of its Asian competition.

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

Six Sigma was applied for two main reasons: requests from the main multinational customer and requests by top management to reduce the number of 'products not compliant (NC)' that result in cost increases and the risk of delay to deliveries.

4.2.1 Changes introduced

The introduction of this methodology had a significant impact in terms of change that involved the main figures and departments in the different phases. The QC Department, the production responsible and the line controllers have been involved for a period of seven months:

- definition: one month
- measuring: two months
- analysing: one month
- improving: two months
- controlling: one month.

The biggest change introduced concerned the measuring systems and much work has been done on this, which proved to be inaccurate using the measurement statistical analysis (MSA).

To bypass this criticality, a visual system for 'non-compliance' accompanied by a document of control for the final test phase has been implemented. Once the first difficulties in the interpretation of data deriving from the processes had been overcome, Six Sigma permitted a decrease in 'NC' products and increases in line personnel competencies, with results immediately apparent after the improving phase (Burke et al., 1995). Data showed correct standards and allowed employees to be part of a production line with the goal of creating efficiency more than flexibility.

Therefore, the two production lines dedicated to the main customer have been redesigned with the aim of reducing the waste deriving from unproductive handling or personnel movement. Nevertheless, to date the production system is not yet optimised and still results in waste – even if considerably reduced from 2.99% to 0.38%.

MFG must work on the organisation of the registration of NC pieces and on HR training in this sense: on a daily basis, operators place NCs in bags marked with the machine ID number, and workers dedicated to QC inspect these pieces and insert data in a file uploaded into Minitab. Each operator is trained in a particular way: it has become necessary to invest in the use of statistics for the analysis of collected data and the development of skills related to decision-making (for evaluation of the NC pieces).

From a technical point of view, machinery has been optimised through the identification of a design of experiment (DOE) with optimum settings and standardised calibrations (in the past this had been left to operators' sensitivity/perception).

4.2.2 New jobs and professionalism

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

In this sense, Six Sigma allows personnel to understand how data can drive through the identification of permanent solutions. Resistance to change was therefore reduced in

the face of objective data. The mindset of employees has dramatically changed in favour of the diffusion of the 'kaizen' philosophy, alibi reduction and active participation in 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 jobs and professionalisms have been developed; an example can be the 'Six Sigma team' created to control the measuring system for statistical data analysis, the implementation of new improvement projects and the stabilisation of the new processes. It is evident that statistical skills are required for team members as well as the ability to work in teams and manage projects.

4.2.3 Main resistances

In the early stages of implementation, the most widespread sentiment was fear, from the point of view of both the workers and the entrepreneur: the main concerns for the employees were around the evaluation process, while for the entrepreneur the risk of no return on investment in terms of the HR involved. For this reason, the entrepreneur put pressure on the team to give feedback before the appropriate time.

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

4.2.4 The role of the consultant

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

The main difficulties encountered by the consultant were related to obtaining a real commitment to improvement activities, which were often delayed to make time for routines 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 interacted with the company HR Department, in this case s/he was decisive in the creation of the Six Sigma team and in the resolution of problems related to the workforce (training plans).

5 Discussion and conclusions

From the first round of studies conducted we can affirm that all four hypotheses were confirmed.

As far as H1 was concerned (*H1*: 'Six Sigma drives SMEs through changes in working processes and job contents, pushing the adoption of a long-term holistic and systemic vision of the company rather than a fragmented and short-term one') we can affirm that the introduction of Six Sigma finally produced changes in the business culture in both SMEs investigated. Achieving the aim of creating a culture of QC, waste and non-compliant reduction, productivity enhancement, speeding up the technical and production processes and continuous improvement, the first results of the analysis highlighted the central and critical role of HR management on two interdependent sides: the introduction of a new culture and mindset and the redesign of the way of working.

Regarding the second hypothesis (*H2*: 'Six Sigma creates new job opportunities and new professionalism inside SMEs') we can affirm that decision-making based on data transformed HR management. Current activities and processes were redesigned and new jobs and new levels of professionalism were created. Statistical skills have been required, as has the ability to work in team and manage projects. A project-driven management approach and a new culture of data management to support decision-making and process improvements appeared to be central in the new work organisation.

In the service company the introduction of Six Sigma allowed the growth of the skills of the designers, speeding up their output with a consequent great improvement in customer service guaranteed by constant monitoring and control of data. In the manufacturing company the limited attitude towards data management represented the most significant obstacle. The main problem was the high rate of non-compliant products. The introduction of Six Sigma led to their reduction, together with increases in line personnel competencies with results immediately perceived after the Improve phase.

Regarding the third hypothesis (*H3:* 'Also in SMEs, after initial reluctance and resistance, Six Sigma stimulates the creation of a culture of continuous motivation, empowerment and accretion') in both cases, resistance to change was reduced in the face of objective data. In both companies, owners started to trust the project after the first results were achieved, and their commitment and support grew, with positive effects on the whole project. DMAIC, as a disciplined data-driven approach, has demonstrated its efficacy in supporting fact-based decision-making, with benefits and positive impacts on customer focus, employee involvement, continuous improvement and transformational leadership.

The analysis of the two cases highlighted general increases in motivation, engagement, satisfaction and trust at all levels for employees, managers and owners.

Regarding the final hypothesis (*H4:* 'the support of a consultant – acting as facilitator – can be determinant in all the different DMAIC phases') we verified that change-management activities are developed not only through investments in new equipment but particularly through new work procedures and personnel competencies

that required training to develop an attitude of flexibility and ability to adapt. In SMEs, the consultant plays the dual role of trainer and consultant, acting as facilitator in the different DMAIC phases; this appeared to be a trait common to both the cases considered.

The consultant maintained focus on the project and on changes introduced with continuity in terms of deadlines and obstacles to be overcome. Basically, consultants lead the project through transformational leadership, showing a better future and motivating the efforts of the moment. These psychological aspects made the difference in both cases.

The culture of data, QC and continuous improvement, a project-driven management approach and new work organisations supported the success of decision-making and new company organisations based on data through DMAIC as a disciplined data-driven approach. The change-management activities carried out on the HR management side and the presence of consultants turned out to be the two success factors of the introduction of Six Sigma into the two SMEs. In particular, the consultants acted as agents of change. They supported the management in realising the changes required by the implementation of Six Sigma. In fact, a structured approach to carrying out processes and activities, new job contents and a culture based on data are not common practices for organisations of this size. With the contribution of the consultants, the timing of the project was planned and respected, overcoming obstacles and difficulties. The two firms reached a higher level of performance in terms of quality, cost reduction and productivity, essential drivers when competing in increasingly difficult markets. Job redesign, new working practices and worker motivation and engagement through the adoption of effective HR practices were key points in the change processes in the two SMEs analysed.

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 though they were 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 HR in the success of the implementation process in its enormous complexity. The in-depth analysis of the two cases highlighted the areas to be managed when handling a project of such difficulty. Since this area of research needs to be explored from an academic point of view, the research should aim to follow up the analysis conducted here through the identification of other cases to evaluate the evidence already emerging.

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References

Aij, K.H. and Teunissen, M. (2017) 'Lean leadership attributes: a systematic review of the literature', *Journal of Health Organization and Management*, Vol. 31, Nos. 7/8, pp.713–729.

Aij, K.H., Visse, M. and Widdershoven, G.A. (2015) 'Lean leadership: an ethnographic study', *Leadership in Health Services*, Vol. 28, No. 2, pp.119–134.

Al-Atiyat, A., Ojo, A.O. and Soh, P.C.H. (2021) 'Impact of Six Sigma critical success factors on productivity improvement through absorptive capacity in the manufacturing industry in Saudi Arabia', *International Journal of Productivity and Quality Management*, Vol. 32, No. 4, pp.536–556.

Albeanu, M. and Hunter, I. (2010) *Six Sigma in HR Transformation: Achieving Excellence in Service Delivery*, Taylor and Francis Group, Abingdon.

Albliwi, S., Antony, J., Lim, S.A.H. and van der Wiele, T. (2014) 'Critical failure factors of lean Six Sigma: a systematic literature review', *International Journal of Quality and Reliability Management*, Vol. 31, No. 9, pp.1012–1030.

Ali, Y., Younus, A., Khan, A.U. and Pervez, H. (2021) 'Impact of lean, six sigma and environmental sustainability on the performance of SMEs', *International Journal of Productivity and Performance Management*, Vol. 70, No. 8, pp.2294–2318.

Alnadi, M. and McLaughlin, P. (2021) 'Critical success factors of Lean Six Sigma from leaders' perspective', *International Journal of Lean Six Sigma*, Vol. 12, No. 5, pp.1073–1088.

Bidikar, S.G., Rane, S.B. and Potdar, P.R. (2022) 'Product development using design for six sigma approach: case study in Switchger industry', *International Journal of Systems Assurance Engineering and Management*, Vol. 13, No. 1, pp.203–230.

Brun, A. (2011) 'Critical success factors of Six Sigma implementation in Italian companies', *International Journal of Production Economics*, Vol. 131, No. 1, pp.158–164.

Burke, R.J., Davis, R.D., Kaminsky, F.C. and Roberts, A.E.P. (1995) 'The effect of inspector errors on the true fraction nonconforming: an industrial experiment', *Quality Engineering*, Vol. 7, No. 3, pp.543–550.

Cho, J.H., Lee, J.H., Ahn, D.G. and Jang, J.S. (2011) 'Selection of Six Sigma key ingredients (Kls) in Korean companies', *TQM Journal*, Vol. 23, No. 6, pp.611–628.

De Koeijer, R.J., Paauwe, J. and Huijsman, R. (2014) 'Toward a conceptual framework for exploring multilevel relationships between Lean Management and Six Sigma, enabling HRM, strategic climate and outcomes in healthcare', *The International Journal of Human Resource Management*, Vol. 25, No. 21, pp.2911–2925.

De Oliveira, M.A., Pereira, M.S., Lima, R.M. and Vieira, A.F. (2021) 'Lean practices to improve the learning process and production document control: a case study', *International Journal of Productivity and Quality Management*, Vol. 33, No. 2, pp.157–179.

Deeb, S., Bril-El Haouzi, H., Aubry, A. and Dassisti, M. (2018) 'A generic framework to support the implementation of six sigma approach in SMEs', *IFAC-PapersOnLine*, Vol. 51, No. 11, pp.921–926.

Eisenhardt, K.M. (1989) 'Building theories from case study research', *Academy of Management Review*, Vol. 14, No. 4, pp.532–550.

Gastelum-Acosta, C., Limon-Romero, J., Tlapa, D., Baez-Lopez, Y., Tortorella, G., Rodriguez Borbon, M. and Navarro-Cota, C.X. (2022) 'Assessing the adoption of critical success factors for lean six sigma implementation', *Journal of Manufacturing Technology Management*, Vol. 33, No. 1, pp.124–145.

Gutiérrez, L.J.G., Bustinza, O.F. and Molina, V.B. (2012) 'Six Sigma, absorptive capacity and organizational learning orientation', *International Journal of Production Research*, Vol. 50, No. 3, pp.661–675.

Hornstein, H.A. (2015) 'The integration of project management and organizational change management is now a necessity', *International Journal of Production Management*, Vol. 33, No. 2, pp.291–298.

Loh, K.L., Mohd Yusof, S. and Lau, D.H.C. (2019) 'Blue ocean leadership in lean sustainability', *International Journal of Lean Six Sigma*, Vol. 10, No. 1, pp.275–294.

Maijala, R., Eloranta, S., Reunanen, T. and Ikonen, T.S. (2018) 'Successful implementation of lean as a managerial principle in health care: a conceptual analysis from systematic literature review', *International Journal of Technology Assessment in Health Care*, Vol. 34, No. 2, pp.134–146.

Maneesh, K., Jiju, A. and Tiwari, M.K. (2011) 'Six Sigma implementation framework for SMEs: a roadmap to manage and sustain the change', *International Journal of Production Research*, Vol. 49, No. 18, pp.5449–5467.

McAdam, R. and Laffert, B. (2004) 'A multilevel case study critique of Six Sigma: statistical control or strategic change?', *International Journal of Operations and Production Management*, Vol. 24, Nos. 5–6, pp.530–549.

Montes, F.J.L. and Molina, L.M. (2006) 'Six Sigma and management theory: processes, content and effectiveness', *Total Quality Management*, Vol. 17, No. 4, pp.485–506.

Panayiotou, N.A., Stergiou, K.E. and Panagiotou, N. (2021) 'Using Lean Six Sigma in small and medium-sized enterprises for low-cost/high-effect improvement initiatives: a case study', *International Journal of Quality and Reliability Management*, ahead-of-print.

Pandey, B., Yadav, V., Singh Chauhan, A. and Rathore, A. (2022) 'Process improvement using lean tools: a case from carpet manufacturing industry', *International Journal of Productivity and Quality Management*, Vol. 35, No. 1, pp.117–142.

Patel, A.S. and Patel, K.M. (2021) 'Critical review of literature on Lean Six Sigma methodology', *International Journal of Lean Six Sigma*, Vol. 12, No. 3, pp.627–674.

Pereira, L., Rodrigues, A., Da Costa, R.L., Gonçalves, R. and Martins, L. (2021) 'Effect of organisational culture on organisational performance – the case of security sector', *International Journal of Productivity and Quality Management*, Vol. 34, No. 3, pp.293–318.

Poksinska, B., Swartling, D. and Drotz, E. (2013) 'The daily work of lean leaders – lessons from manufacturing and healthcare', *Total Quality Management and Business Excellence*, Vol. 24, Nos. 7/8, pp.886–898.

Psarommatis, F., Sousa, J., Mendonça, J.P. and Kiritsis, D. (2021) 'Zero-defect manufacturing the approach for higher manufacturing sustainability in the era of Industry 4.0: a position paper', *International Journal of Production Research*, Vol. 60, No. 1, pp.73–91.

Puram, P. and Gurumurthy, A. (2021) 'Celebrating a decade of international journal of lean six sigma – a bibliometric analysis to uncover the 'as is' and 'to be' states', *International Journal of Lean Six Sigma*, Vol. 12, No. 6, pp.1231–1259.

Rodriguez, R.D., Medini, K. and Wuest, T. (2022) 'A DMAIC framework to improve quality and sustainability in additive Manufacturing – a case study', *Sustainability (Switzerland)*, Vol. 14, No. 1, p.581.

Santana Lambert Marzagão, D. and Carvalho, M.M. (2016) 'Critical success factors for Six Sigma projects', *International Journal of Project Management*, Vol. 34, No. 8, pp.1505–1518.

Schroeder, R.G., Linderman, K., Liedtke, C. and Choo, A.S. (2008) 'Six Sigma: definition and underlying theory', *Journal of Operations Management*, Vol. 26, No. 4, pp.536–554.

Singh, G. and Singh, D. (2020) 'CSFs for Six Sigma implementation: a systematic literature review', *Journal of Asia Business Studies*, Vol. 14, No. 5, pp.795–818.

Singh, M. and Rathi, R. (2019) 'A structured review of lean six sigma in various industrial sectors', *International Journal of Lean Six Sigma*, Vol. 10, No. 2, pp.622–664.

Singh, M. and Rathi, R. (2021) 'Investigation and modeling of lean six sigma barriers in small and medium-sized industries using hybrid ISM-SEM approach', *International Journal of Lean Six Sigma*, Vol. 12, No. 6, pp.1115–1145.

Singh, M., Kumar, P. and Rathi, R. (2019), 'Modelling the barriers of lean six sigma for Indian micro- small medium enterprises: an ISM and MICMAC approach', *The TQM Journal*, Vol. 31, No. 5, pp.673–695.

Sodhi, H.S. (2021) 'Lean Six Sigma in food industry: a case study', *International Journal of Productivity and Quality Management*, Vol. 34, No. 3, pp.336–349.

Sordan, J.E., Oprime, P.C., Pimenta, M.L., Chiabert, P. and Lombardi, F. (2020) 'Lean Six Sigma in manufacturing process: a bibliometric study and research agenda', *The TQM Journal*, Vol. 32, No. 3, pp.381–399.

Soundararajan, K. and Reddy, K.J. (2020) 'Productivity and quality improvement through DMAIC in SME', *International Journal of Productivity and Quality Management*, Vol. 31, No. 2, pp.271–294.

Sparrow, P. and Otaye-Ebede, L. (2014) 'Lean management and HR function capability: the role of HR architecture and the location of intellectual capital', *The International Journal of Human Resource Management*, Vol. 25, No. 21, pp.2892–2910.

Sreedharan, V.R., Raju, R., Sunder, M.V. and Antony, J. (2019) 'Assessment of lean six sigma readiness (LESIRE) for manufacturing industries using fuzzy logic, *International Journal of Quality and Reliability Management*, Vol. 36, No. 2, pp.137–161.

Stone, D.L. and Deadrick, D.L. (2015) 'Challenges and opportunities affecting the future of human resource management', *Human Resource Management Review*, Vol. 25, No. 2, pp.139–145.

Thomas, A. Barton, R. Chuke-Okafor, C. (2009) 'Applying lean Six Sigma in a small engineering company – a model for change', *Journal of Manufacturing Technology Management*, Vol. 20, No. 1, pp.113–129.

Tiwari, S.K., Singh, R.K. and Srivastava, S.C. (2022) 'An integrated Lean Six Sigma model for enhancing the competitive advantage of industries', in Agrawal, R., Jain, J.K., Yadav, V.S., Manupati, V.K. and Varela, L. (Eds.): *Recent Advances in Industrial Production. Lecture Notes in Mechanical Engineering*, Springer, Singapore.

Yadav, G., Seth, D. and Desai, T.N. (2018) 'Application of hybrid framework to facilitate lean six sigma implementation: a manufacturing company case experience', *Production Planning and Control*, Vol. 29, No. 3, pp.185–201.

Yadav, V., Gahlot, P., Kaswan, M.S., Rathi, R. and Singh, M. (2022) 'Sustainable green lean six sigma methodology and application status: a perspective review', in *Recent Trends in Industrial and Production Engineering*, pp.251–266, Springer, Singapore.

Zu, X. and Fredendall, L.D. (2009) 'Enhancing Six Sigma implementation through human resource management', *Quality Management Journal*, Vol. 16, No. 4, pp.41–54.

Zu, X., Fredendall, L.D. and Douglas, T.J. (2008) 'The evolving theory of quality management: the role of Six Sigma', *Journal of Operations Management*, Vol. 26, No. 5, pp.630–650.