World class manufacturing and "Six Sigma": Their application to SMEs, as well as to services

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Abstract: *The present work starts with the observation of the current international crisis that has not spared the business world, affecting mainly the industrial sector.*

Thus, companies are now more than ever called upon to ensure their competitiveness by meeting some critical success factors that are not only related to quality and product innovation, but also to the production efficiency which can be achieved through minimizing both production and delivery costs.

The difficulty of combining the fulfilment of these objectives which seem to be in contrast with each other, has led companies to experiment different management philosophies to find the most suitable to be adopted in the competitive scene in which they operate, and aimed at ensuring the best business performance in the medium-long term.

As a result, the research aims, first, at investigating whether there are management philosophies that are able to meet these objectives, supported by operational approaches that are compatible with their basic criteria; secondly, it is meant to assess whether these models may cover the whole industrial sector rather than a single sector alone, as well as whether they can be used in both large companies and SMEs (Small and Medium Enterprises) and, finally, whether they can be extended to service companies as well.

Key words: International crisis, Firms, Strategies, WCM, Six Sigma.

1. Introduction

Through analysing the current phase of globalization, it turns out that, like the previous ones, it is characterized by a series of historical events (such as the American merchant banks' bankruptcy and the recent wars in the Middle East), that are having serious economic, social and financial repercussions on the international markets.

However, unlike earlier phases, it is to be noted that the current one is marked by

its own distinguishing feature, namely the growing importance of the human being in the decision-making process, concerning the product demand and supply. In fact, in modern economies, it is the customer that "leads" the market and that, by his choices, makes a firm either successful or unsuccessful according to the quality and efficiency offered.

Nevertheless, the above two factors of corporate success can be fulfilled solely through better exploiting the role played by man in the firm, since the latter relies on this resource to implement plans aimed at improving the corporate production process in order to ensure increased competitiveness of the firm in the market.

What is described above leads to a consideration on the current industrial scene showing a clear contrast between two main competitive trends, namely those related to the simultaneous maximization of efficiency and effectiveness; the former is achieved through a drastic reduction in the cost of the product from its being conceived until its decline (life cycle cost); the latter is reached through shortened delivery time and increased flexibility to match promptly the changes involving the market which, as it is described above, is increasingly controlled by the final consumer.

As a result, companies are increasingly required to implement management policies that are able to operate with a view to constantly improving not only the product and the production process but also the other business components such as the staff, the management, the executive and operational level control systems, the information system and so on.

Starting from this consideration, the present paper is aimed at investigating first, the management philosophy that companies are willing to implement to meet the critical success factors mentioned above; such a philosophy seems to have been identified, at least in the automotive sector, in the approach that is known as World Class Manufacturing (WCM), namely an integrated system aimed at preventing production waste.

Obviously, to be successful, this approach should also be supported by an "operational philosophy" preventing both defects and errors; such a philosophy seems to have been identified in "Six Sigma" methodology, pertaining the telecommunications industry.

Thus, starting from the literature on the subject and after introducing the automotive industry competitive context where WCM management philosophy has developed, the principles on which it is based will be discussed later and subsequently compared with those underpinning "Six Sigma" which covers a different sector; then, by examining the production and financial data concerning companies from various industrial sectors, it will be possible to assess the effectiveness of the two approaches in terms of a cost-benefit analysis.

Finally, in the light of the analysis carried out on some Italian firms' case studies, the present paper will also assess whether the above two philosophies can be exploited in other industrial sectors apart from those which are peculiar to them, as well as whether these approaches can be used in service companies besides manufacturing companies; ultimately, the work will investigate whether their use is limited only to large companies or whether, instead, it can also be extended to SMEs (Small and Medium Enterprises).

2. Literature review

The globalization of markets has significantly changed the business strategies aimed

at creating value for the customer (Porter 1993). In fact, in the past, the competitive market was controlled by a few large industrial companies which decided the product to be marketed; besides, the static nature of demand allowed the company, based on the hierarchical-functional model, to produce a standardized product for mass consumption, thus easily yielding both economies of scale and high profits (Butera 1994).

At present, on the contrary, more and more "aggressive" competitors together with negative economic trends are urging increasingly competitive challenges that are paradoxically contrasting in terms of cost, quality and product delivery time (lead time) (Donna 1992), requiring industrial excellence in terms of flexibility, innovation, service level and efficiency, which are likely to be achieved with a flat organizational structure focusing on those processes that can create value for the final consumer who is increasingly going to be master in the market (Arata Andreani and Furlanetto 2002; Jeannet 1994; Merli and Biroli 1996).

For this reason, the only way of reining in such a situation is to reorganize and not only to readjust the company's logistics and production process in order to make it lean, fast and responsive, with no waste and fully under control (Champy and Hammer 1994; Drucker 1999; Johansson et al. 1994; Mariotti 1994; Ostinelli and Toscano 1993).

In fact, the evolution of markets has led to the change of the primary factors that brought about the "Lean revolution"; such factors can be described as follows:

- the gradual reduction in the life cycle of the product;
- the difficulty of reliably predicting demand for the final product and its components;
- the impossibility of correctly calculating the load input to the production system which, therefore, turns out to be irregular;
- the increased range of final products demanded by the market, needed to satisfy increasingly demanding and prepared customers through increasingly wide and varied supply;
- the growing and overwhelming competition from emerging countries' competitors that are difficult to be countered both on the cost and on the quality side.

From the above, it is clear that it is no longer possible to focus exclusively on optimizing the processing cycle, but it is necessary "to learn to identify" waste in transfers, handling, stocks, controls, defects, lead time, errors, repairs, etc., which represent the bulk of the costs to be borne without any added value for the customer.

This need is also confirmed by the analysis of the defects concerning different types of companies (Table 1), showing that, especially in recent times, the application of a new management philosophy is more and more necessary in order to reduce the number of defects arising from the production process so that to increase the business competitiveness.

Given the current international situation, a radical reinterpretation of the production process is increasingly needed, in order to meet successfully the new requirements of the market.

In order to achieve this goal, World Class Manufacturing (WCM) (Keegan 2003; Strever 2008) was worked out, which represents a modern evolution of the Japanese model known as the "Toyota Production System"

(Cusumano 1985; Liker 2004) that developed in the automotive industry in the eighties and consists in an Innovative Production System based on such techniques as Lean Production, Total Quality Management (TQM), Total Productive Maintenance (TPM) and Just-in Time (Golhar and Stamm 1991), aimed at a rapid and continuous improvement in the whole logistics and production cycle of the company, through eliminating any kind of waste and loss (Muda), which can be achieved only by involving the company's human resources at all organisational levels, through the strict application of the suitable standards and methodologies such as "Six Sigma" (Adams et al. 2003; Basu and Wright 2004; Brue 2003; George 2002; Gruppo 2G 2010; Schonberger 1987).

Table 1 *- Percentage of defects in certain types of manufacturing companies and services*

TYPOLOGY OF PRODUCTION/SERVICE	% defect
Motorcycle – At the end of the assembly line	*30%*
Aluminium piece working- Reworking and scraps	*7%*
Tractors - Tractors with some defect	*100%*
Gas valve – Faulty pieces at the end of the line	*15%*
Cosmetics – Assembly	*20%*
Taps and fittings – Pressing	*7%*
Insurance –Accident policy from brokers	*80%*
Banks – First level control for credit granting	*60%*

3. World Class Manufacturing (WCM) management philosophy

What is described above shows that the main purpose of WCM is, therefore, to be successful on the market with high quality products at competitive prices, by meeting customer needs and ensuring maximum flexibility, through the strict application of "zero defects in everything" formula, namely the "nine zeros" on which this management philosophy relies, represented by: zero customer dissatisfaction, zero mismatches, zero bureaucracy, zero shareholders' dissatisfaction, zero waste, zero non-value adding work, zero stops, zero missed opportunities, and zero lost information (Strever 2008).

From a purely strategic point of view, WCM System is based on three meanings (Bordogna 1994):

- the sense of innovation, meant as the search for a way to do something better than it has ever been done before;
- the sense of achieving quality through constantly pursuing a perfection standard made up of details;
- the sense of efficiency, as a result of reduced waste.

Reducing waste means, therefore:

- eliminating non-quality costs;
- investing in better functioning of the business processes and in human skills;
- delivering value and customer satisfaction, achieving a competitive advantage in the long term.

In order to achieve these goals, the key actions to be pursued when applying this philosophy are thus summarized as follows:

- improving processes;
- avoiding waste and correcting errors;
- detecting errors before they become defects;
- investing the resources saved in Value adding activities for the customer;
- displaying waste through scientific observation and a graphic display of flows.

In this respect, the means to ensure the Rapid Improvement required, to be achieved by the company, are the following:

➤The Deployment system consisting in analysing the value chain to detect waste, as well as carrying out the plant Rightsizing showing that about 30% of resources are dedicated to non-value adding activities for the customer;

➤The Value Stream Mapping, based on a graphic display of all the actions that are normally required to transform the raw material into the final product for the customer, identifying 30 to 40% waste as well as its causes within a week;

➤The Kaizen Week, which is an approach to improvement actions allowing remarkable results to be achieved in just five working days, through shifting from the brainstorming to the trainstorming which allows the improvement ideas to be tested on the spot, as much as possible within a day, by the people involved in the process, that will obviously take the suitable precautions on the matter.

It is to be noted, that before the advent of WCM, it was assumed that production could be managed "in numbers". The numbers were to be used to decide the actions to be taken, the materials to be bought, the people responsible for such actions to be identified.

If, for example, the latest report on costs showed a negative variance for the welding operation, the task of reducing costs fell on the department head. But how? There were no data on the causes that had led to cost overruns. The department head could, for example, put the staff under pressure to achieve a higher output for the same labour cost but, nevertheless, in this way, he would not have been able to understand what had really happened. Basically, numbers were not able to clear up the causes of this phenomenon, as well as to go back to the real reasons leading to cost overruns.

In most cases, they could not even identify the symptoms of the real problems affecting the balance sheet.

With the introduction of WCM, instead, the first thing to be done is trying to identify the causes that produced those numbers, going back to the "root causes", and then to remove (or at least to minimize) the factors producing them. In this case, numbers indicate the quality of products and services, as well as of the improvements achieved in terms of costs over time.

Briefly, WCM essentially allows the problems to be measured, diagnosed and solved directly within the factory, avoiding learning them afterwards through the reports and the balance sheet, by which time, nothing can be done any longer.

It starts with the elimination of any kind of waste in the factory and then goes even deeper, also focusing on eliminating waste concerning the organizational structure, as well as the management practices. It is focused on customer satisfaction, through a good knowledge of customer needs, on the basis of which it aims at offering a high quality final product at affordable prices.

However, in order that WCM management approach develops properly, it must

first be implemented by the Directorates General that, through a powerful leadership action, are in charge of spreading and applying its principles, leading the company to reach high quality levels at competitive costs.

In fact, history teaches us every day that the greatest resource available to a business is people rather than technology. Focusing on people rather than on technology and giving them a chance to use their potential is the key to "world class" competitiveness.

In short, pursuing excellence means striving for "perfection" with a goal of Continuous Improvement. Such an improvement must be achieved through a "bottom-up" approach, i.e. by fully involving the operational staff taking full care of details.

4. The results that can be achieved through WCM implementation in different kinds of companies

After explaining the principles supporting WCM, it is necessary to assess the validity of this management philosophy, to understand whether it is likely to match the current competitive context and to benefit the companies adopting it, both economically and qualitatively. The analysis carried out has revealed that WCM is able to achieve significant results such as:

- 100% increased productivity;
- 90% shrinkage in both stock and production time;
- 50% reduction in both errors for the customer and in scraps for the process;
- 50% reduction in Time to Market;
- low extra cost supply of a wider range of products;
- very modest investment.

Besides, once adopted, WCM allows productivity to be doubled, over time, through incremental improvements over two or three years, as well as stock-in-trade, errors and time to be halved over the same space of time.

Waste, namely "non-quality cost", ranges between 10% and 30% turn-over in most companies and the improvement process may be endless, bordering on perfection.

As for "waste hunting", consisting in the rapid improvement activities carried out during the Kaizen week, it allows significant results to be achieved, as it is shown by the data below relating to technical features (Table 2), as well as to the rapid improvements attained within some companies covering specific industrial sectors (Table 3).

***Table 2** – Business performance improvements through the use of the Kaizen Week*

TYPOLOGY OF RESULTS	% result
Increased productivity	*from 20 to 60%*
Reduced work in progress	*from 30 to 70%*
Reduced defects	*from 20 to 40%*
Reduced set-up time	*from 50 to 80%*
Reduced metres to be covered	*from 40 to 80%*

Table 2 – Business performance improvements in different kinds of companies

HOUSEHOLD APPLIANCE COMPANY			
Features	**Starting**	**Goal**	**Result**
Space (sq.m.)	*75*	*60*	*57 (-25%)*
Stock	*40*	*10*	*10 (-75%)*
Lead Time (min.)	*24*	*6*	*6 (-75%)*
Cycle Time (cts)	*298*	*240*	*203 (-32%)*
HOUSHOLD ELECTRONICS COMPANY			
Features	**Starting**	**Goal**	**Result**
Production (piece/day)	*500*	*600*	*600 (+20%)*
Team (operators)	*5,5*	*5*	*5 (-10%)*
Stock turnover index	*7,6*	*60*	*60 (+680%)*
Space covered	*100 mq.*	*-50%*	*50 (-50%)*
AID SERVICES AND PERSONALIZED ASSISTANCE TO THE INVOICE PROCESS			
Features	**Starting**	**Goal**	**Result**
Defects	*70%*	*100%*	*95%*
Lead Time	*71 days*	*12 days*	*12 days (-83%)*

5. "Six Sigma" operational methodology

Continuous improvement of the processes underlying WCM management philosophy that has just been examined, the application of which is considered as crucial to ensure the business competitiveness in the current international scene, as it is shown by the data analysed, implies the following actions: redesigning either the product or the service offered, improving the production process effectiveness and efficiency, carefully monitoring costs and margins, reducing defects and errors in supplying products and services, meeting customer needs faster, increasing the employees' professionalism and so on.

Therefore, given the cross-nature of the possible interventions, the task of improving performance requires a structured approach, a disciplined, coordinated and well organized "thinking", as well as appropriate business resources' involvement.

Among the most developed WCM-based operational methodologies, the so-called "Six Sigma" is worth mentioning; it is a modern and very rigorous approach to running a business, whose aim is pursuing excellence, based on TQM and Continuous Improvement principles.

It is an "operational philosophy" that can be described as an approach to the business improvement, aiming at identifying the critical points and the causes of defects in order to eliminate the most relevant and damaging mistakes, by reducing time and transaction costs, improving productivity and better meeting customer needs.

Introduced in the early eighties from Motorola, a leader in the field of mobile phones, this methodology has gained considerable credibility over time, so that its guidelines have been agreed upon by such

organizations like General Electric, Toyota, Honeywell, and Fiat (the last one has implemented it in its Italian factories as well as abroad, namely in the newly-born plant in Kragujevac, in Serbia) (Scalera 2011), thus certifying worldwide "Six Sigma" approach (Vergnano 2010), as a real philosophy for analysing, measuring, as well as improving the business processes; in addition, Motorola was identified as the international reference for its quality approach.

Starting from the basic idea according to which each process shows some variability due to natural and specific causes that can be potentially identified, controlled as well as eliminated and without going into a highly statistical explanation of the methodology, it is perhaps useful to define the Critical to Quality (CTQ) factors, namely all those features that are peculiar either to a product or a process, that must meet certain criteria (specifications) in order to avoid customer dissatisfaction.

Consequently, the term Process Capability is meant as the quality level of a process that can be defined as the degree according to which the process output meets the specifications (target values) defined for CTQ characteristics.

In order to assess that the characteristics of either goods or services comply with the validity limits imposed by the specifications, it is, therefore, necessary to check the process creating a product/service rather than the product/service in hand. Which means shifting from an investigation into the product obtained to an investigation into the process creating the product, through the use of dedicated techniques.

These include "Six Sigma" among the best, a technique measuring the variance of a process, namely a parameter fluctuation against its average value (standard deviation); besides, unlike compliance with the ISO 9000 family of standards, "Six Sigma" covers not only quality but also the economic field. "Sigma", as the methodology is known, comes from the Greek letter that is used in statistics to indicate the value of a process variance, namely a parameter fluctuation against its average value (the so-called standard deviation).

The indicator is calculated using a simple algorithm that will define the number of "Defects Per Million Opportunities" (DPMO) using the following formula:

DPMO = [D/(NxO)]x1000000

where:

D = Defects produced per unit of time.

N = Number of output produced per unit of time.

O = Number of defect opportunities per unit of output.

The sigma scale is an exponential conversion scale associating each DPMO with a sigma value: the lower the DPMO, the higher the sigma value.

The highest quality attainable by applying "Six Sigma" methodology is just equal to "six" and the more this value is approached, the more the process is stable and therefore less subject to the variance.

A "Six Sigma" quality reaches 99.99966% accuracy rate, which means no more than 3.4 defects per million items produced (Brun 2008).

Going further into details, the necessary steps to develop this methodology can be described as follows:

- obtaining support by the top management;
- appointing either the Steering Committee or the Business Quality Council members;

•gathering information through contacts with customers, suppliers and partners;

•training and awakening the management, as well as the employees to the methodology;

•developing the monitoring system by defining objectives, resources and performance indicators (by establishing the project charter);

•creating working groups and selecting the processes to be improved;

•launching the projects with special care to the first measurable results achieved.

The above methodology is very popular for a number of advantages:

a) simple and easy to be used;

b) the opportunity to compare processes that are very heterogeneous between them;

c) helping the company to set ambitious targets to be achieved through Continuous Improvement approach;

d) spreading and applying the approach aimed at involving both the employees and the management.

However, in order that its application is actually successful, the top management must be convinced of the project effectiveness, invest in the employee's training and spread a corporate culture within the firm, aimed at awakening the employee to taking on responsibility, at decentralizing decision-making as well as at promoting the initiative by the worker. It is clear that this cultural change within companies leads to the creation of a special infrastructure of people who are going to redefine roles within the company's organizational structure.

Among these new professional profiles, five are needed for suitable "Six Sigma" implementation in the business.

• Executive Leadership includes the CEO as well as other key members of the Top Management. They are responsible for setting up a vision for "Six Sigma" implementation.

They also empower the other role holders with the freedom and resources needed to explore new ideas for improvement..

• Champions are responsible for "Six Sigma" implementation across the various functions in an integrated way and are drawn by the Executive Leadership from upper management.

• Master Black Belts, namely in-house resources that are selected by Champions, acting as experts and coaches for "Six Sigma" implementation. They play this role full-time and besides assisting Champions and guiding Black Belts and Green Belts, they have the task of identifying new projects to be developed, dealing with the integration of projects among the various business functions, as well as ensuring a suitable and rigorous application of the statistical techniques in the ongoing projects.

• Black Belts operate under the guidance of Master Black Belts to apply "Six Sigma" to specific projects, even guiding Green Belts. They play this role full-time and their work is focused on the implementation of projects, while Master Black Belts are primarily oriented towards the identification of new areas for improvement.

• Finally, Green Belts are the employees who, in addition to their specific roles and job responsibilities, devote a part of their time to implementing "Six Sigma" projects.

6. DMAIC as a methodology to improve a process "Sigma"

Among the methodologies aimed at enhancing the Sigma level achieved in a process, the most widespread is DMAIC (the

acronym for the words Define, Measure, Analyze, Improve and Control).

In this general framework, DMAIC is the data and information analysis that is peculiar to "Six Sigma", structured and focused in order to make decisions and test them before actually committing the business resources needed to improve existing processes. The advantage of this decision-making approach does not lie in its phase structure in itself, but rather in the content of each single phase, since this is the factor that makes the method systematic.

To better understand this methodology, it is useful to briefly describe the content of the various phases characterizing it.

➤The first phase, corresponding to "Define", aims primarily at describing in a clear and unambiguous way the purpose of the project, the improvements to be achieved and how to measure them, laying the foundations for the development of subsequent phases. In order to be suitably supported by the top management, the improvement project must provide a tangible impact on the strategic business objectives and therefore on the customer satisfaction (either internal or external to the organization), fixing the operation economic return, the sectors involved, the economic and human resources needed and the project schedule.

➤The "Measure" phase, instead, aims at measuring, by using descriptive statistics and sampling, the current status of those features which are critical to the quality or the business that are to be modified, as it is described in the "Define" phase. The team must then collect the data concerning the product, service or process to assess the current level of performance and provide a picture of the initial state of the context (often referred to as an as-is situation).

In practice, once the characteristics of the product, service or process have been identified along the "Define" phase, it is necessary to understand and measure both the inputs that may affect them, and the outputs achieved with these input values, by structuring the information that are essential for the subsequent analysis phase.

➤In the "Analyze" phase, starting from the data collected, information are gathered that are useful to implement the improvement process by using such tools as the analysis of variance (ANOVA), Pareto histograms, regression, correlation and stratification.

Therefore, this stage is meant to understand how each input in the process and each transformation within itself affects the output, namely the performance; in other words, the "root causes" of the problem tackled are to be detected, as well as the factors to be considered in order to achieve the goals set.

➤The "Improve" phase, a systematic search for solutions is carried out through a creative process involving all the team members, to reach a large amount of ideas and proposals through the use of FMEA (Failure Modes and Effects Analysis), DOE (Design of Experiments), as well as a cost-benefit analysis.

Among the intervention opportunities that have been put forward, the most profitable ones must be identified, according to the economic standards or to other parameters that are relevant to the organization, by making a selection of the possible projects.

Once the interventions for improvement have been selected, a pilot project is worked out that confirms their costs and benefits, either testing its impact for a limited space of time, on a limited set of products or working on an partial area of the process.

➤In the last phase, the one known as "Control", the results achieved through the changes made must be confirmed and kept steady over time or their benefits should be widened as much as possible through the following: the planning activity, the control tools and documents that are needed to transfer the knowledge acquired through the project, the implementation and application of the successful solutions found to other business sectors; all these activities will be carried out by using such instruments as the control chart, as well as the quality control plan.

Finally, the last activity should be focused on the evaluation of the work done by the project team, as well as the communication of the possible goals achieved through a public acknowledgement of the results achieved by the working group, the staff's involvement and, basically, the spreading of the improvement culture within the company.

However, in case of new processes that have to be still designed, the earlier phases, though keeping the same meaning, may be changed, leading to the approach indicated by the DMADV acronym. It is characterized by the following:

- Defining the process and identifying its weak points that lead to failing to meet customer expectations;
- Measuring the process and determining whether it meets customer expectations;
- Analysing the options needed to satisfy the customer;
- • Designing changes to the process in order to satisfy the customer;
- Verifying that the changes made have met customer expectations.

7. Italian companies case studies

At this point, starting from the analysis of some case studies, the object of the present study is to assess whether the use of WCM at a management level and of "Six Sigma" at an operational level can be applied successfully to Italian service companies, apart from production companies, as well as whether their use may be extended to SMEs.

Afterwards, the work is intended first to identify the most important critical success factors to be met to implement the methodology in Italian companies and then to compare such factors with the "traditional" cases that emerge from the various publications on the subject.

In particular, for the sake of accuracy, among the twenty companies surveyed, the five most significant cases illustrated below, cover heterogeneous sectors, of various size, that have implemented the methodology both in existing processes and in the new projects.

•The first company to be considered is Leasys and Savarent (Fiat Group Automobiles), which is the long-term renting platform of Fiat Auto Group, that employs about 450 employees and covers about 150,000 vehicles. The implementation of "Six Sigma" has been directed at eliminating waste that, in a service business, leads to such malfunctions as stacked sheets and drawers crammed with papers (Doglio 2009).

The use of the Kaizen week has allowed the introduction of the visual element within the continuous improvement system in order to show the defect, a result that was also achieved through the monthly interview on the customer network.

However, in particular, Value Stream Mapping, namely the mapping of all the

business processes considered as value flow for the customer rather than as an input/output system, developed within a week, has been essential to reduce the process variability and obtain a significant economic return amounting to about 5 million, against advice costs and 100% dedicated resources which resulted in a total investment of 400 million Euros.

• Another service company is Enel, the market leader in Italy in the field of energy networks, that invested about 2.5 million Euros in 2006, to launch an operational excellence project known as "Lean Six Pegasus" aiming at reducing costs of about 700 million Euros (of which only 250 million Euros were made in 2008), spreading the culture of the methodology among about 20,000 people in the department.

The results went far beyond expectations, leading to 20% reduction in the resources used by eliminating 30 non-value adding activities, as well as a set of hierarchical constraints that slowed down decision-making (Doglio 2009).

Finally, the optimization of the stock and materials management process, started in 2009, is expected to ensure 150 million Euros saved over three years, while in the near future, the Lean concept will also apply to suppliers by integrating the entire supply chain, as well as to issues relating to the environmental impact (with the processes of Green Identity and Lean Green Division).

• As regards Box Marche joint-stock company, it is a company operating in the field of graphic as well as paper and cardboard industry, that has set itself an ambitious economically and socially-oriented mission, namely that of achieving excellence on the basis of ethical principles that are able to promote comfort not only for customers but also for suppliers, employees, partners, the territory and the outside community (Del Baldo 2008).

This result was achieved by introducing "Lean Six Sigma" culture, which led to highly satisfactory results; in fact, stock shrank by 25% and lead time was reduced, on average, by 10% (Greco 2009).

• Among SMEs, Emmevi limited company has successfully implemented "Lean Six Sigma" methodology; the company, dealing with designing and manufacturing small and medium power electric motors, has focused its attention on solving the problem concerning the reduction in the number of orders processed later than the time set by the customer (a week's delay in 30% of cases and over a five days' delay in 25% of cases).

In particular, once the department has been identified, namely the fan department which was the critical quality feature, the application of the methodology made it possible, by a 20% reduction in non-value adding for the customer, to increase the daily productivity of over 1,000 pieces for each work shift thus reducing the order delay (Aggogeri and Sicorello 2009).

• Finally, again among SMEs, Ticinese Service limited company, that is specialized in supplying industrial refrigerating units ordinary and extraordinary maintenance services, had, at the beginning, some difficulties in efficiently managing and supplying its service.

The problem was mostly domestic, since the calls and orders covered ensured that performance targets were met.

In this case, the problem was solved by using DMADV problem solving, since the action was taken on something that did not

exist yet, by designing and implementing a system that was able to manage and measure all the services offered, leading to zero organizational errors, thanks to the creation of a streamlined organizational structure consisting in a team of four operators carrying out maintenance, as well as a staff of three people in charge of marketing, customer management, planning services as well as business management (Aggogeri and Sicorello 2009).

In the light of the cases analyzed and of the satisfactory results achieved through "Six Sigma" application, it can be seen that this methodology is a cross-sector one, as it is the most effective to improve any business area and any kind of performance.

However, it can be seen that the basic principles of Lean Production can be extended to the office context, as well as to services, although in Italy there are still few companies that have gone through this innovative step (Galgano 2005; Sganzerla 2004).

The reasons for this partial development are manifold.

First of all, there is to be noted, in fact, that in offices and services the production flow is less evident and, furthermore, the customer can often cause waste through interfering in the process.

Other reasons are accounted for by the fact that quality and productivity interfere with each other, that in these areas there is a clear human predominance against machinery and materials, and that individuals have little experience in identifying and separating what creates value from what does not create it.

Finally, it is shown that in these sectors, productivity improvements, when turned into economic benefits, negatively affect the redistribution of surplus staff.

8. The success factors of "Six Sigma" implementation in an Italian business

At this point, in order to overcome the difficulties described above in Italian companies, it is useful to identify the most important critical success factors leading to successful implementation of "Lean Six Sigma" methodology in those firms.

The answer is evident by comparing the methodology implementation in a dozen Italian companies and the "traditional" cases worldwide, emerging from various publications on the subject.

In order to carry out this analysis, the answers from Italian and foreign company's managers were analysed, about the most important critical success factors to be met in order to develop the methodology, as it is shown by the results set below, considering that for each factor, the average value (on a scale from 1 to 5), as well as the standard deviation of the results achieved were taken into account (Table 4).

The analysis of the above data shows that successful implementation in Italian SMEs must meet the same critical success factors as international companies, mainly represented by:

- involving the top management as well as entrepreneurs in the improvement project;
- associating cultural change with a "Six Sigma" programme implementation;
- linking the programme made with the aforementioned methodology and the business strategy.

From the above, a series of reflections can be made concerning WCM implementation at management level, as well as "Six Sigma" application at the operational level, in Italian companies.

• In particular, barriers to improvement can be overcome if structured and appropriate action is taken, represented primarily by training on the job aimed at providing all employees with the technical knowledge needed for the proper application of the above methods to those processes that must, sometimes, be reformulated, to ensure their continuous improvement.

• In addition, the effort to be made to carry out "Six Sigma" training programme decreases with increased length of implementation in the company. This is mainly due to the fact that, as already shown in the first phase of the methodology development within the company, it requires considerable effort on the part of the business to train, first, Black Belts that will, afterwards, have the task of training the rest of the staff so that the latter are receptive to the use of the new method.

***Table 4** - Significance of the Critical Success Factors*

	Traditional Application		**Italian SMEs**	
Critical Success Factors	**Average**	**Deviation Standard**	**Average**	**Deviation Standard**
F1: Management involvement and commitment	*4.4*	*0.31*	*4.5*	*0.31*
F2: Cultural change	*3.9*	*0.36*	*4.0*	*0.51*
F3: Communication	*4.0*	*0.64*	*3.8*	*0.77*
F4: Organisational infrastructure	*3.5*	*0.80*	*3.4*	*0.81*
F5: Education and Training	*3.7*	*0.60*	*3.6*	*0.71*
F6: Linking Six Sigma to business strategy	*4.1*	*0.27*	*4.0*	*0.55*
F7: Linking Six Sigma to customer	*3.9*	*0.45*	*3.8*	*0.86*
F8: Linking Six Sigma to human resources	*3.4*	*0.86*	*3.4*	*1.04*
F9: Understanding tools and techniques within Six Sigma	*3.7*	*0.55*	*3.7*	*0.49*
F10: Linking Six Sigma to suppliers	*3.6*	*0.78*	*3.3*	*0.90*
F11: Project management skills	*3.6*	*0.57*	*3.7*	*0.59*
F12: Project prioritisation and selection	*3.8*	*0.55*	*3.7*	*0.43*

Source: Brun, A. 2008. From Performance to Decision. Business Intelligence & Business Performance Management for Business Efficiency. Milan Politecnico and Bergamo Confindustria, July 8, 2008. Accessed March 16, 2011. http://www.unindustria.bg.it/i/club/qualita/file/8lugli08brun.pdf

The analysis of the above data shows that successful implementation in Italian SMEs must meet the same critical success factors as international companies, mainly represented by:

- involving the top management as well as entrepreneurs in the improvement project;
- associating cultural change with a "Six Sigma" programme implementation;
- linking the programme made with the aforementioned methodology and the business strategy.

From the above, a series of reflections can be made concerning WCM implementation at management level, as well as "Six Sigma" application at the operational level, in Italian companies.

•In particular, barriers to improvement can be overcome if structured and appropriate action is taken, represented primarily by training on the job aimed at providing all employees with the technical knowledge needed for the proper application of the above methods to those processes that must, sometimes, be reformulated, to ensure their continuous improvement.

•In addition, the effort to be made to carry out "Six Sigma" training programme decreases with increased length of implementation in the company. This is mainly due to the fact that, as already shown in the first phase of the methodology development within the company, it requires considerable effort on the part of the business to train, first, Black Belts that will, afterwards, have the task of training the rest of the staff so that the latter are receptive to the use of the new method.

Later, by the time passing and as the methodology spreads within the company, in a more advanced stage, training will cover only Green Belts, that, among other things, having a good knowledge of their function processes will be able to maximize the value created by "Six Sigma", devoting only a part of their time to the projects implemented by using this tool, so that to spend the remainder to perform their own duties.

•Besides, it must be pointed out that the application of the methodology requires a significant commitment by companies that sometimes, especially SMEs, are unable to support, due to high training costs, as well as to their exclusively short-term view of the matter. Among other things, training programmes should be extended to all hierarchical levels, providing Black Belts with the use of the latest statistical methods, and Green Belts with less complex ones (Fig. 1).

In particular, Black Belts should work full time, so the high opportunity cost related to the withdrawal from their own membership functions, suggests that small businesses should limit the use of these figures, focusing, instead, on increasingly involving Green Belts.

•It was noted that companies trained in "Six Sigma" at all hierarchical levels implement a greater number of projects based on this methodology, since by approaching the methodology and being in close contact with the processes to be improved, even the operational levels will have a practical and active attitude in solving the problems to be tackled.

•Another point to be discussed concerns the minimum targets for improvement to be set by the companies, in order to approve the launching of a "Six Sigma" project, which is sometimes influenced by the selection of indicators either of a financial nature or not.

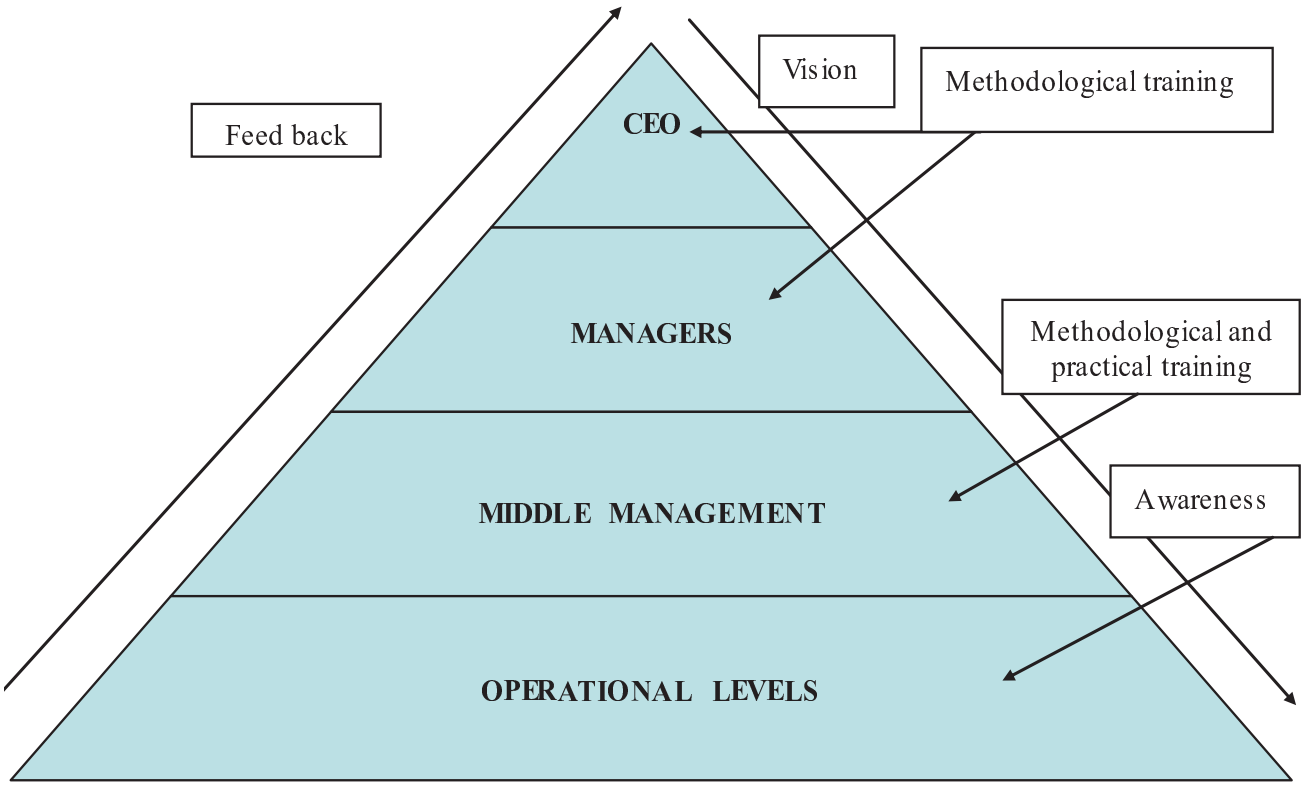
In this regard, one of the objectives of "Six Sigma" implementation is, essentially, to work out efficient projects in the economic sense of the term, without neglecting projects directed at improving quality performance, so as to continuously pursue customer satisfaction.

• A final consideration concerns the projects' quality level and the possible outcomes to be achieved over time.

In fact, it was pointed out that the most suitable approach is to implement, in the early years of the methodology application, simple projects showing a high probability of success, in order to convey confidence to the staff; afterwards, once the early stages are over, higher minimum targets will be considered to remove the causes of the project's inefficiency allowing improvements to be made more easily.

Finally, once the methodology implementation has reached its full development stage and processes have been remedied, the quality level achieved should be kept steady; in fact, considering "Six Sigma" in a dynamic perspective, it will reach a saturation level, since it is not actually possible to reach a level of absolute perfection.

Figure 1 *- Framework of Reference for Training*



Source: Brun, A. 2008. From Performance to Decision. Business Intelligence & Business Performance Management for Business Efficiency. Milan Politecnico and Bergamo Confindustria, July 8, 2008. Accessed March 16, 2011. http://www.unindustria.bg.it/i/club/qualita/file/8lugli08brun.pdf

9. Conclusions and implications

The present work was intended to identify a managerial philosophy that, properly supported by an operational methodology, enabled companies striving for competitiveness in the current international recession to pursue customer satisfaction, combining goals seemingly in contrast with each other, that is to say, the product quality and innovation on the one hand and production efficiency on the other one, through minimizing production and delivery costs.

The paper has established that these goals can be achieved by applying World Class Manufacturing (WCM) management philosophy to companies, aiming at eliminating defects in all business processes, working with a view to their improvement, that can be achieved by avoiding waste through correcting errors, in order to invest the resources saved in activities creating value for the customer.

The analysis has shown the validity of this philosophy that, if adequately supported by "Six Sigma" operational methodology based on the same principles, can successfully result in the following: 100% increased productivity, 90% reduced stock and production time, as well as 50% shrinkage in such items as Time to Market, errors for the customer and scraps for the process.

At this point, the object of the paper was to answer three questions, namely: understanding whether these approaches could be applied to the Italian context in all productive sectors, whether their validity could be influenced by the company's size, as well as whether their use could also be extended to service companies.

The analysis of the case studies has shown that the answer is positive to all the three questions.

Indeed, in the light of the satisfactory results achieved by applying "Six Sigma", it can be seen that this methodology is a cross-sector one, as it is the most effective to improve any business area and any kind of performance; besides, it can lead to satisfactory results, regardless of the company size; in fact, some case studies have proved its perfect applicability to SMEs as well, that will need less technical, financial and human resources to implement it (by involving Green Belts).

Moreover, as it was shown by the cases analysed, WCM and its "Six Sigma" operational methodology may contribute economic and quality advantages, even in service industries.

The latter, however, will be likely to have some difficulties related to the Italian political, cultural and social context that, combined with the small-medium sized businesses often based on a hierarchical model, implies objective difficulties for the management, that are mainly related to engaging and motivating the staff at all levels, instilling deep confidence in the method, overcoming the false fear that the "world class" approach cannot be applied to their own context, creating and effectively managing cultural change, going beyond the boundaries of the functional model by working in team aiming at improving the aggregate value flow across all the business functions.

In particular, among the problems to be solved, there is primarily the high variability in quality that does not allow easy control of the same performance to be replicated over time.

Secondly, the value intended as a benefit for the customer, which is considered to

be highly subjective and intangible, can lead to some difficulty in understanding what are the features that are likely to increase value for the customer himself.

In this area, another important element is the time factor, since the availability or not of the service for the customer, at a particular time, determines whether or not value is created for him.

As to some kind of malfunctioning considered as waste in this area, they are different from that concerning the production sector, and are represented by non-completed paperwork within the process on hold, on computers or in the drawers, by missing information and documents, as well as by the amount of paper that is actually moved from one location to another.

Finally, in my opinion, the present research suggests that easier and successful implementation of the above methodology in the context of Italian companies, in the near future, requires a number of critical success factors to be fulfilled, among which the most important are represented by the following: involving both the top management and entrepreneurs in the improvement project, associating cultural change with "Six Sigma" implementation through the company's training, as well as linking the programme implemented with the above-mentioned methodology and the business strategy used.

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