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Managing design for Six Sigma in new service development: an exploratory study

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MANAGING DESIGN FOR SIX SIGMA IN NEW SERVICE DEVELOPMENT: AN EXPLORATORY STUDY

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ABSTRACT

During the latter part of the 20th century, the service sector significantly grew in every developed country, as well as global competition and the pressure to offer new services to satisfy customer needs. However, whereas there has been a respectable amount of research in the service management literature, research specifically in the context of New Service Development (NSD) was very little.
The application of the Six Sigma approach in new product or new service design has been defined as Design For Six Sigma (DFSS). While several have been the authors that have investigated the impact of the DFSS method to product design, scientific research on applications of DFSS on the NSD process is very scant.
The purpose of the paper is to investigate the impact of implementing DFSS to NSD process and to develop a set of lessons about how companies should implement this methodology to service processes. An exploratory case study has been launched in an American lead telecommunications company that has applied DFSS to services. The work highlights that such implementation has led several benefits to the firm. The strategic, organizational and operational procedures that the firm has adopted to successfully implement the method in this context are reported in the paper.

KEYWORDS: Design For Six Sigma, New Service Development, Service Quality, Exploratory, Case Study.

INTRODUCTION

During the latter part of the 20th century, the service sector significantly grew in every developed country, with the United States taking the lead (Heineke and Davis, 2007). In the most advanced countries, more than half of gross domestic product is in the service sector, which is expected to rule economics and job growth through the 21st century (Pilat, 2000). Moreover, global competition and technological change is growing worldwide, as well as the pressure to offer new services to satisfy customer needs (Menor *et al.*, 2002).

However, whereas there has been a respectable amount of research in the service management literature, there has been very little research specifically in the context of New Service Development (NSD) (Alam and Perry, 2002). Existing research suggests that new services are mostly developed through unorganized and unsystematic processes and in literature there are no generally accepted methodologies on this focus (Menor *et al.*, 2002). Clancy and Shulman (1991) assert, for example, that in the financial service industry a new service failure rate of 80% has been reported. More in general, Johne and Storey (1998) claim that a large proportion of NSD is not successful. Therefore, it seems evident that further research on NSD is requested in order to overcome these problems.

The application of the Six Sigma approach in new product or new service design has been defined as Design For Six Sigma (DFSS) (Antony and Bañuelas Coronado, 2002; Schroeder *et al.*, 2008). DFSS is an organized and systematic method for the strategic improvement and for the new product and process development using statistical tools in order to drastically reduce defects perceived by customers (Linderman *et al.*, 2003). This method can allow organizations to design products or services at a six sigma level of quality, meeting or even exceeding customer expectations through the use of established tools and techniques (Kwak and Anbari, 2006; Tennant, 2002; Mader, 2002).

Over the last decade the literature on Six Sigma has steadily grown. The most frequent applications have regarded the improvement of existing processes in manufacturing and services, using its well-established method, i.e. the DMAIC model, while publications on DFSS have been fewer. Furthermore, while several have been the authors that have investigated the impact of the DFSS method to product design (Antony and Bañuelas Coronado, 2002; Chakravorty, 2009; Bañuelas Coronado and Antony, 2004; Goel and Chen, 2008), scientific research on applications of DFSS on the NSD process is very scant.

The purpose of the paper is to investigate the impact of implementing DFSS to NSD process and to develop a set of lessons about how companies should implement this methodology to service processes, focusing on both managerial and technical aspects. This study is therefore guided by the following research questions:

> RQ 1. The application of DFSS to NSD has a positive impact on firm's performances?
>
> RQ 2. What are the best practices that firms must own to successfully implement DFSS to services?

To answer these research questions, following the indications of Yin (2003), an exploratory case study has been launched in an American lead telecommunications company that has applied DFSS to services. The need for exploration is underlined by the necessity to analyze new and potentially innovative practices and examine the difficulties of implementing new techniques and procedures (Scapens, 1990). Furthermore, empirical research on DFSS applications in service processes is totally lacking and this study fills an important gap in scientific literature on Six Sigma.

The work highlights that applying DFSS to services has positively impacted on the process of NSD, leading several benefits to the firm. Moreover, the company has adopted both strategic,

organizational and operational procedures to successfully implement the method in this context.
The paper is structured as follows. The part 2 shows the theoretical background on NSD, Six Sigma and DFSS. The part 3 reports the research methodology. In part 4, the case study in the telecommunications sector is presented; after the firm description, the evolution of Six Sigma in the company is reported, describing the systems adopted by the enterprise to successfully implement DFSS to NSD process, eventually. Finally, in part 5, the discussion summarizes the relevant points as well as outlines the limitations of this study, addressing further developments both academic and managerial on this field.

LITERATURE REVIEW

New Service Development

Several are the authors who defined or classified the concept of "New Service".
For Lovelock (1984), new services are defined in terms of the product or service outcomes (or offerings). The extent of change to the existing service system or based on the operational process and participants, instead, was the basis of the definition of Tax and Stuart (1997). Normally, the nature of the topic leads to consider production and delivery of service in a systemic approach, described as "service concept", i.e. the way the service offering is to be delivered (Shostack, 1984; Fitzsimmons and Fitzsimmons, 2001). Stevens and Dimitriadis (2004) specify that the modification of the service offering require the transformation of some elements of the service concept.
Some authors (Menor *et al.*, 2002) assert that changes to the service concept requiring new skills from the existing operation are considered as a new service. The same authors, considering both what service is offered, i.e. the newness of the service offering and how service is delivered, i.e. the service concept, define as new service an offering not previously available to a company's customers. Such new service results from the addition of a service offering or modifications in the service concept that allow for the service offering to be made available.
Although literature dealing with NSD is quite limited if compared to new product development (NPD) (Menor *et al.*, 2002), recently the interest on the topic has grown and several authors have studied NSD processes (Stevens and Dimitriadis, 2005; Carbonell *et al.*, 2009; Droege *et al.*, 2009).
Since the beginning, the issue whether NPD processes can be implemented to NSD has always been debated. Dolfsma (2004) is convinced that different processes are required for NPD and NSD. Nijssen *et al.* (2006) resume this argument describing two antithetical approaches in literature. The "assimilation approach" has outlined that because of their similarity, concepts developed in a product context can be implemented in a service context. On the other way, the "demarcation approach" asserts that service context is completely different from manufacturing context, hence, concepts and models must be specifically designed for services.
One of the first models on NSD process was presented by Scheuing and Johnson (1989) and consisted of two parts: service design, including service purpose and design stages and the delivery process, including testing and introduction stages. Grönroos (1990), in order to develop the offering of the service created a dynamic six-stages model, considering both organizational and customer features. The NSD model of Edgett and Jones (1991) includes 18 stages and focuses on communication with the personnel delivering the service as well as the support of the senior management during the process of service development. The model of Edvardsson and Olsson (1996) is strongly customer-focused, but it is not divided by

phases. The model, indeed, distinguishes three different processes: service concept development, service system development, and service process development. Furthermore, the authors claim that these three components have several kinds of interrelationships that depend on the type of the service development project. Another interesting model composed of seven stages was presented by Tax and Stuart (1997). The authors attempt to integrate the existing service system with the potential new service, analyzing the original firm's service system, customer's needs and the extent of change, in order to assess the effects that the new service could have on the existing service system. Finally, the NSD model of Alam and Perry (2002) consists of ten phases: strategic planning, idea generation, idea screening, business analysis, formulation of a cross-functional team, service design and process system design, personnel training, service testing and pilot run, test marketing and commercialization. The main characteristic of this model is the particular attention focused on customer integration in the service development process, topic recently discussed also by Carbonell *et al.* (2009).

Six Sigma

In the last decades, several scholars have investigated on Six Sigma methodology, e.g. Bañuelas and Antony (2002), Linderman *et al.* (2003), Antony (2006), Savolainen and Haikonen (2007), Schroeder *et al.* (2008) and Chakravorty (2009), who have carried on their research on different aspects of the topic.

Some authors (Sousa and Voss, 2002; Chakrabarty and Tan, 2007; Zu *et al.*, 2008; Nakhai and Neves, 2009) studied how Six Sigma and the theory of quality management has evolved through the years. The origins of the methodology are connected with Frederick Gauss, who at the beginning of the 19th century introduced the statistical concept of normal distribution. Walter Shewhart, in 1922 introduced three sigma as a measurement of variability, claiming that quality is low when output went beyond this limit. The three sigma concept can be compared to a process yeld of 99.97 percent or a defect rate of 2700 Defects Per Million Opportunities (DPMO) in the long term. This defect rate was considered the standard for most manufacturing companies, at least until the early 1980s when Six Sigma was created (Raisinghani, 2005). In literature, the benefits that Six Sigma projects bring to the firm have never been disputed, however, some authors (e.g. Naslund, 2008; Kumar *et al.*, 2008) have investigated if Six Sigma is actually an innovative quality improvement method or only a management fad, i.e. a repackaged version of TQM. In summary, both methodologies offer similar and rather general critical success factors, but overall, in TQM seems to be missing the need for a systemic approach to organizational change and improvement (see also Andersson *et al.*, 2006).

The purpose of Six Sigma is decreasing the defect rate and costs by reducing the variability in the processes (Naslund, 2008). Revere *et al.* (2004) claim that the method brings to different kinds of benefits, e.g. increasing financial results, reducing wastes and improving customer service.

In the companies, Six Sigma has been implemented in several ways. Harry and Schroeder (2000) refer to the methodology as a top-down company-wide managerial strategy. Breyfogle *et al.* (2001) assert it is simply a set of quality tools and techniques, while other authors (Magnusson *et al.*, 2004; Johannsen and Leist, 2009) consider Six Sigma as a systematic improvement program in which business processes are optimized by means of a prescribed methodology. Several different definitions are present in literature and Linderman *et al.* (2003), defining it as "An organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates", stress the need for a common definition. For Bañuelas and Antony (2002) is "A philosophy that employs a well-structured continuous improvement methodology to reduce process

variability and drive out waste within the business processes using statistical tools and techniques"; Chakrabarty and Tan (2007) claim it is "A quality improvement program with a goal of reducing the number of defects to as low as 3.4 parts per million opportunities or 0.0003 per cent"; Kwak and Anbari (2006) consider it as "A business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceeds customer needs and expectations". Finally, about taxonomy, besides "philosophy", "program", "strategy" and "method", Sousa and Voss (2002) refer to Six Sigma as a "practice".

In order to explain the nature of Six Sigma and building theory on the topic, Schroeder *et al.* (2008) outlined five elements in this methodology.

First regards the importance of management's involvement in executing several Six Sigma activities, e.g. selecting improvement specialists, identifying project selection, and facilitating the methodology's implementation. Also Antony *et al.* (2007) underline the relevance of management's involvement in on-going projects for sustainability of Six Sigma programs. Second, the Six Sigma organizational structure, also known as parallel-meso structure, in which improvement specialists, i.e. Green belts or Black Belts, receive internal or external training. Third, Six Sigma programs have performance metrics and measurements based on cost, quality, and schedules. Fourth, the implementation of Six Sigma is based on a five-step systematic procedure, i.e. the DMAIC (Define, Measure, Analyze, Improve, Control) model. Fifth, project selection is a fundamental element in Six Sigma programs. As regards project prioritization, Bañuelas *et al.* (2006) suggest several tools, e.g. cost benefit analysis or the Pareto priority index.

Beyond these elements, Brady and Allen (2006) include two more principles. The first stresses the care to the bottom line in initiating projects. The second emphasizes the significance of the training of non-statisticians in order to use some statistical tools with minimal theory.

Although the scholars have paid much more attention on the implementation of the methodology to the manufacturing sector, in the last years there is a growing number of publications on the applications of Six Sigma to services. Several are the common myths about Six Sigma that have been debunked in literature (Kumar *et al.*, 2008). In particular, Nakhai and Neves (2009) have investigated if the methodology is good only for manufacturing processes, highlighting the possible limitations and opportunities of Six Sigma applications in service industry. Therefore, the authors, after summarizing the potential applications on this context, assert the effectiveness of the methodology in improving the quality of services (see also Antony, 2006; Antony *et al.*, 2007).

However, in order to succeed and not to obtain only marginal benefits, this program should be correctly and skilfully implemented (Foster, 2007). Also in the service processes, firms can apply the DMAIC model (Antony, 2006), a series of well-defined steps whose characteristics can be summarized as follows:

1. Define: the service process to be improved is mapped; customer requirements and expectations of stakeholders are gathered; performance standards are determined; a project charter is realized;
2. Measure: the actual performance of the process is determined; process data are gathered;
3. Analyze: a detailed analysis of process data is conducted by means of statistical tools so that the causes for deviations in the process performance can be identified;
4. Improve: the team develop solutions to improve process performance; project plans are created in order to implement the solutions previously determined;

5. Control: the actual performance of the process is continuously monitored; corrective actions are identified to sustain the improved performance level.

Several tools and quality techniques are implemented in each phase, and some authors (Brady and Allen, 2006) have strongly attempted to associate these tools with specific phases of the application.

Design For Six Sigma

Implementing the Six Sigma approach to NPD or NSD in order to deliver products or processes at a six sigma level of quality has been defined Design For Six Sigma (DFSS) (Antony, 2002). Kwak and Anbari (2006) have claimed that DFSS is a systematic approach that can enable organizations to design products or services that meet or exceed customer expectations, employing well-established tools and techniques. For Bañuelas and Antony (2002) is increasingly more difficult shifting sigma capability while getting closer to six sigma level. The authors assert that when a company reaches 4.8 sigma, a change of paradigm is needed and strategy is not defect removal anymore. Therefore, process and services are completely re-designed, in order to achieve more easily six sigma levels.
Antony (2002) assert that implementing DFSS can lead to the following benefits:

- Reduction of time to market for new or revised products;
- Reduction of life cycle costs associated with products;
- Better analysis of the Voice of the Customer;
- Reduction of number of design changes;
- Quality and reliability improvement for products and services;
- Improved risk management in design;
- Reduction of warranty costs.

While for the improvement of existing processes the DMAIC model represents a well-established approach, in literature several authors (El-Haik and Roy, 2005; Chakrabarty and Tan, 2007) have described the application of DFSS using different models (e.g. DMADV, ICOV, DCCDI, DMEDI). Although the acronyms are different, the implementation is pretty the same (Seifert, 2005). The initial phases strongly focus on understanding customer needs and requirements to identify a level of performance that could not only satisfy, but even delight the customer. Afterwards, there are three high level deliverables: the design of the proposed process, a test design to forecast the performance of the process and a pilot test. Finally, in the last phase the main purpose is to verify the design's performance, making improvements where needed and keeping on monitoring the full scale deployment for a period.
Chakrabarty and Tan (2007) assert that the DFSS methodology includes tools and techniques that are quite different from those implemented in the DMAIC model, e.g. innovation tools as the theory of inventive problem solving (TRIZ), axiomatic design and quality function deployment (QFD).
Benefits from the application of DFSS are potentially much more evident than DMAIC, since its implementation starts with scratch in the early stage of new product or new process development. In summary, extensive research has already been developed on the application of DFSS in a manufacturing context, and considering new areas of DFSS implementation, such as service processes, could represent a valuable opportunity.

RESEARCH METHODOLOGY

The present work is exploratory, with the final purpose to identify the main managerial practices that firms must adopt to successfully implement DFSS to services.

The choice of a case study research is one of the most appropriate method of empirical inquiry and definitely fits with our purposes, because qualitative studies give explanation of quantitative findings in operations management (Meredith, 1998; p. 441).

Yin (2003, p. 86) describes case studies as an appropriate research strategy if the type of questions being posed are "how" and "why" where the researcher has little control on events and the focus of the research is on a phenomenon within some real-life context. Since the novelty of the topic is showed in literature, which indicate that more theory on Six Sigma is needed (Antony, 2006), the case study methodology results particularly suitable for new studies (Yin, 2003, p.86) and the single case study for explorative ones (Meredith, 1998; p. 441).

Consequently, a single, in-depth, case study has been chosen, as the phenomenon under exploration demands insights from multiple perspectives within the firm. It was felt, indeed, that this approach would yield greater insight at this exploratory stage than a larger number of shallower case studies. Following the indications of Stake (1995), the case firm was selected based on its representativeness among the companies that implement DFSS to services, in order to maximize what can be learned.

The case study had the main purpose to highlight the implementation levels of DFSS in the NSD, in order to outline the best practices for the process.

The research has been developed in three steps. In the first preliminary step, it has been realized a literature review on Six Sigma, in a systematic way. The literature review highlighted how it is an emerging research field and which are the research gaps outlined by the authors. The second step has been focused on data gathering and analysis. Finally, a second literature analysis contributed to analyze and make sense of the bunch of data previously gathered.

In further studies, the data of the case studies will be used for theory development following the process proposed by Eisenhardt (1989) and Voss *et al.* (2002), which provide a good and proven possibility to build theory from case study research.

To acquire a deep understanding of the dynamics involved, multiple data collection methods were adopted. These are references to official company's documents (website and archival documents), press review and interviews.

The aim was twofold: to increase information basis and to diversify data, in order to reduce biases (Eisenhardt, 1989; Patton, 2002; Yin, 2003).

Documentation proved exact and broad coverage, allowing the researchers to review details of events (Yin, 2003, p. 86) and to triangulate information with the interviews.

Multiple respondents were considered in order to reduce subjectivity and biases of single informants (Voss *et al.*, 2002, p. 205). The respondents were two Six Sigma Master Black Belt dealing with new products and new services development and a Master Black Belt currently moved to another company who was in charge of the same activities.

At the beginning the interviews were open, in order to deepen the background of the interviewees. Afterwards, the protocol has scheduled semi-structured interviews (Arksey and Knight, 1999), in that a previously prepared list of questions was used as guideline. However, the list was used in a way that let the respondents feel as free as possible to talk about the overall subject, sharing their own ideas and feelings to ensure that no important arguments were left out. All interviews were carried out by conference call (due to geographical distance of the company). They were taped and transcribed accordingly, to better find conflicting answers and review their contents.

The transcriptions were analyzed by the authors and then compared with previous documentation. The analysis refers to a period from September 2009 to January 2010. The researchers gave meaning to the bunch of data by reorganizing them in three patterns, that refer to the main procedures adopted by the firm:

1. Strategic;
2. Organizational;
3. Operational.

Summarizing, the exploratory study was structured as it is shown in Figure 1:

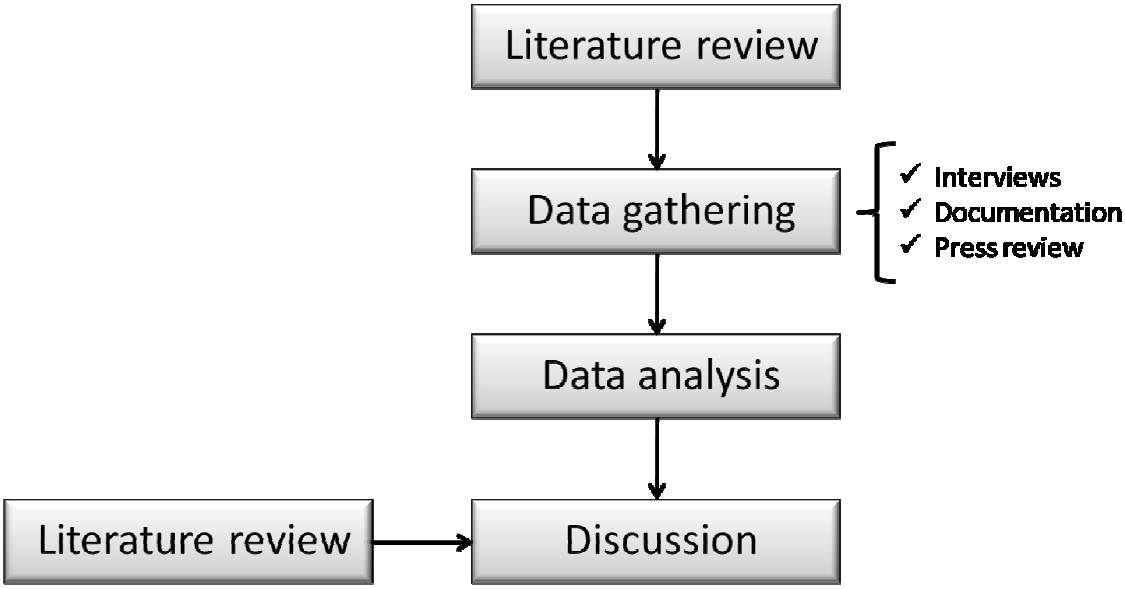

Fig. 1: Methodological steps.

CASE STUDY

Firm description

This paper is focused on the study of an American lead company operating in the telecommunications industry. SSE (an acronym for Six Sigma Enterprise will be used to preserve anonymity) is a multinational also located in Plantation (Florida, USA) and was chosen due to its historical use of Six Sigma methodology.

Founded in 1928 and quoted in the stock market since 1943, SSE's core business is represented by wireless telephone handsets. Furthermore, it designs and sells wireless network infrastructure equipment such as cellular transmission base stations and signal amplifiers.

SSE is mainly organized into two business units.

The *Mobile Devices and Home* business is set to lead in the convergence of mobility, Internet and new media. Products' portfolio includes mobile converged devices and smartphones, digital entertainment devices in the home, and end-to-end video, voice and data solutions enabling to provide advanced mobile media solutions and multi-screen experiences. Currently the company is working with network operator partners in order to create new advanced personalized services to leverage the capability of expanding wireless and wireline broadband availability.

The *Enterprise Mobility Solutions and Networks* business comprehends an end-to-end portfolio of products and solutions, e.g. mobile computers, rugged two-way radios, secure public safety systems, barcode scanning and wireless network infrastructure to enterprises and governments, as well as 4G broadband infrastructure, devices and services to network operators globally.
Furthermore, SSE offers several kind of services, such as:

- Application services (e.g. Design Services, Application Engineering Services, End-to-End Solutions);
- Integration services (e.g. Equipment Installation Services, Hardware Upgrade Services, Network Migration Services);
- Strategic Mobility Services (e.g. Planning Services, Consulting Services, System Readiness Analysis Services, Logistics Optimization Services);
- Support services (e.g. Remote Monitoring, Preventative/Corrective Maintenance, Software Maintenance, Hardware Support).

The rapid convergence of fixed and mobile broadband Internet and the growing demand for next-generation mobile communication solutions, allowed the company to refine the mission and to lead the next wave of innovative products and services for meeting the expanding needs of the customers around the world. The trends towards ubiquitous connectivity, media mobility and wireless flexibility, joined with mobile lifestyles and business, keep on expanding.
Today, SSE is considered a big multinational, comprehending approximately 66 thousand employees, most of them working in the North-American area.
The SSE 2009 net sales were about US$ 22 billion. United States take the lead with the 54% of the total net sales, followed by Asia (excluding China) and Latin America (11%), Europa (9%) and China (6%). A block of several other countries represent the remaining 9% of the net sales.
In SSE the drive for innovation is noteworthy. The 2009 R&D expenditures were US$ 3.2 billion, while from 1928 the number of patents granted in the company was 23019 (worldwide). This big effort towards communications and electronics industry innovation joined to massive R&D expenditures brought to many technological breakthroughs, e.g. the world's first commercial high-power transistor, the world's first commercial portable cellular phone, the world's first GPRS cellular system.

The role of Six Sigma in the SSE company

Nowadays Six Sigma and Lean Sigma are widely-upheld methodologies and tools used to reduce variation in a business process by using a statistical process control to measure variance and standard deviation (Näslund, 2008).
During the last decades, implementing the Six Sigma methodology, the SSE company has realized several significant developments, becoming a pioneer for technology innovations.
Many organizations agree with the misconception that generating random ideas is essential to developing revolutionary offerings. Contrarily, SSE has placed greater emphasis on the actual process surrounding the identification of opportunities. Innovations are considered those inventions that reach the market (Joh and Mayfield, 2009) and represent a big business. However, they demand considerable investment in finance, time and personnel.
Contrary to common expectations, the search for new business opportunities is often stimulated by periods of uncertainty or even crisis. In this context, since SSE's available resources were often limited, this factor forced us to identify company's priorities. The

company, in fact, had the possibility to choose among several quality improvement initiatives. Since these initiatives were extended to different functional areas of the company, the company had to base its choice on the positive financial impact that the project would bring, but also on the strategic implications in the long term.
In SSE, Six Sigma started in 1987 as a "quality program" and initially it was applied to improve manufacturing processes.
Over the years, the verification of the applicability of Six Sigma outside of manufacturing has led to the gradual evolution of the methodology and to the reinforcement of a shared quality culture.
Conventional thinking says that firms must sacrifice quality to achieve quantity or low cost. SSE and other companies that implemented Six Sigma showed that the opposite is true. In the first five years of implementation the results obtained were astonishing:

- The employee productivity increased 100 per cent;
- Almost US$ 1 billion manufacturing cost savings;
- The defect rate declined from 6000 to 30 DPMO (Defect Per Million Opportunities);
- Cumulative cost savings were in excess of US$ 3 billion;
- 5 per cent added to profit levels;
- Sales increased from US$ 5.9 billion to US$ 13.3 billion.

Due to great results of the first years, Six Sigma methodology continued to evolve in SSE, showing massive financial returns. In 2000 the company began to implement Design For Six Sigma (DFSS). DFSS is a methodology for driving breakthrough performance in new product development. This Six Sigma program is structured around the DMADV model, a five-phase model comparable to other DFSS methods, e.g. ICOV, DMEDI, IDOV and similar to the more traditional DMAIC model. DMADV is about "designing in" quality, cost savings and faster time-to-market. Staudter *et al.* (2009) assert that DFSS methods deal with positive quality, while the DMAIC model deals with negative quality.
In SSE the need for a brand new process comes when occurs at least one of these conditions:

- None of the ways to produce an output is completely accurate;
- No process exists to produce a product or service to satisfy a new customer need;
- The process is considered completely optimized but customer's needs are still not satisfied.

The evolution of Six Sigma in SSE also dealt with taxonomy. What was called "Six Sigma" in 1987, in 2005 finally evolved into "Digital Six Sigma." Digital Six Sigma (DSS) is a management system with a business improvement methodology that focuses on customer requirements, process alignment, timely execution, etc. using applied statistical tools derived from Six Sigma. The current DSS program in SSE integrates principles of traditional "Six Sigma" with "Lean Tools."
There are two main branches of DSS at SSE today, namely, Six Sigma Process Improvement (SSPI) and Six Sigma Product Development (SSPD). SSPI's focus is on eliminating waste and variation in business processes that already exist, using the DMAIC model. SSPD's focus, instead, is about designing new concepts utilizing the Voice of the Customer. These concepts will be mainly used for robust new product development.

Moving to DFSS for service processes

At the beginning of Six Sigma implementation, SSE applied the DMAIC model only to manufacturing processes, representing its core-business. Gradually, the company started to broaden the methodology's application area to internal services, since they can be definitely considered processes. Afterwards, given the excellent results obtained, SSE began to implement the methodology's principles to design robust products and processes, opening the way for the DFSS to develop new services, eventually. The application of DFSS to NSD in SSE does not correspond to a specific name or acronym in the organization. Hereafter in this paper we refer to this activity as Six Sigma Service Development (SSSD).

Figure 2 provides a clear summary of the Six Sigma applications in SSE.

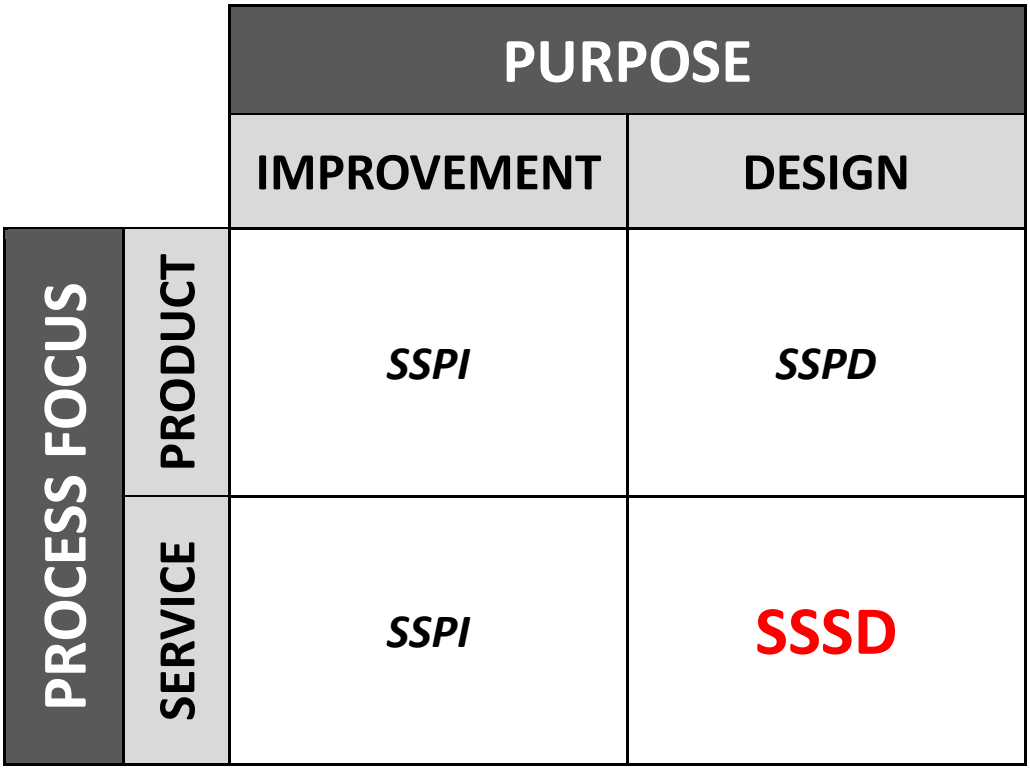

Fig. 2: Six Sigma applications in SSE.

Applying the methodology in service processes represents in SSE a further opportunity for increasing profit levels. Research showed that most of the service processes perform at less than 3.5 sigma quality level with a defect rate of over 23000 DPMO (Yilmaz and Chatterjee, 2000).
SSE overcame the prejudice still conforming to the notion that Six Sigma is relative only to manufacturing mainly implementing and developing the methodology through the three basic principles quoted by Antony (2006):

1. All work occurs in a system of interconnected processes;
2. All processes exhibit variability;
3. All processes create data and it is responsibility of the company to identify the sources of variability and implement effective strategies to reduce or eliminate such variability.

Applying DFSS methodologies for designing and developing new services and in general new processes has definitely led to several benefits in SSE:

- Market share has increased;
- Customer satisfaction has improved;
- Service operational costs (compared to similar services) have been reduced;
- Variability of the main service processes have been reduced;
- Defect rate in service processes has been reduced;
- Improved culture due to a better attitude to quality improvement;
- Process cycle time (compared to similar services) have been reduced.

In order to obtain these benefits and successfully implement DFSS to NSD, SSE has concentrated its efforts towards three main aspects: strategic, organizational and operational.
The strategic aspect mainly deals with the ability of the company to choose the best opportunity for a new service and to translate this opportunity in a Six Sigma project. Beyond to satisfy the needs of the customer, indeed, Six Sigma projects must be accurately chosen in order to fit with the company's strategic priorities.
The organizational aspect deals with the Six Sigma human resources put side by side to the organizational structure of the firm. Furthermore it deals with the company's culture and all the other intangible aspects.
Finally, the operational aspect deals both to the implementation of the methodology in the company and the choice of the best tools to be used in the specific phases during a Six Sigma project.

Strategic aspect

When Six Sigma was born in SSE, the international competition among American companies was quickly increasing. Nowadays, because of this competition, most companies try to do more with fewer resources. Service development methodologies such as SSSD is allowing SSE to launch new services sooner, at lowest cost for the company and with less variation, while satisfying customers. In SSE, the use of DSS is directed to a better comprehension of customers' value and needs. As a matter of fact, the final purpose of the methodology is a business delivering value for its customers (internal or external) and stakeholders in a perfect value stream. The only possibility to achieve this goal is seeking continuous improvement in every process of the company: from strategic planning to service delivery.
Unlike other quality methodologies, a distinctive characteristic of Six Sigma is the project-based implementation. Six Sigma projects are the vehicle that leads to improvement but among thousand good ideas representing potential improvement opportunities, the company has to select some to be implemented.
Bañuelas and Antony (2002) assert that Six Sigma project must have a direct impact on both financial and operations goals and a clear effect on the whole business. On this basis, in every single project SSE tries to identify the link between the project and the business strategy, demonstrating its benefits and how it will sustain the business strategy, not only in financial terms.
Actually in SSE, the Six Sigma projects selection process is extremely important, as it represents the connection between business strategy and the needs of those customers who might receive the service that the company design.

In our opinion, as Goldstein *et al.* (2002) linked the needs of customers and the strategic intentions of the organization with the design of the service (see fig. 3), Six Sigma projects selection could represent the missing managerial link between corporate strategy and customers' satisfaction.

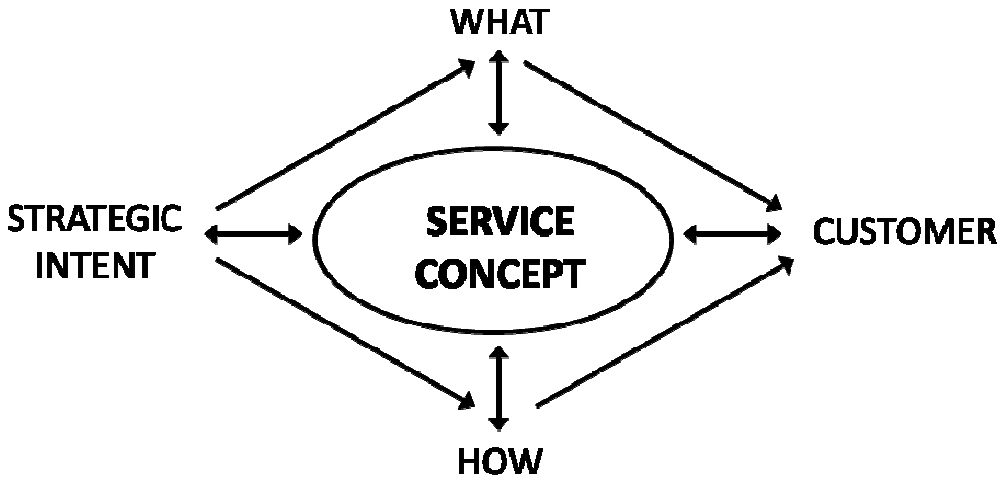

Fig. 3: A proposed link in service design (Goldstein *et al.*, 2002).

SSE, in order to generate service concepts that fit with this purpose, has considered Six Sigma project selection as a strategic process. The aim of this process is selecting only the NSD projects which are aligned to the firm's business strategy and for this SSE is creating formal procedures for the selection process of NSD projects.
Top management in SSE is convinced that NSD projects prioritization should have its basis overall on objective factors. These factors are mainly based on three analysis: a full risk analysis for the NSD projects, a detailed financial analysis and a wide market analysis. The market analysis comprehend a formal study of the market to monitor changes in customer demand, a clear segmentation and the identification of a complete set of customer requirements and actual needs.

Organizational aspect

Since the beginning of its experience with Six Sigma methodology, SSE has used a people-centred approach to drive fundamental changes. This approach required several elements to move towards a new corporate culture.

- The development of new reward and recognition systems based on return on net assets from each major sector (and some smaller groups) of the company;
- Uniform quality measurement and goals through the introduction of the DPMO (Defect Per Million Opportunities) concept in the company;
- The communication of new quality rules to the organization;
- The training of skilled and prepared people;
- Nurturing and supporting facilitators;
- Commitment of senior executives.

In the company, some of these elements have been considered fundamental also for the implementation of DFSS to services. Others evolved in order to better fit the NSD processes.

Finally, the introduction of novel procedures made much easier the evolution of the company's culture towards this new approach.
SSE still has a people-centred system in the firm, indeed, the purpose is that top managers have long term commitment to NSD and senior managements show strong support for this process.
The company has substantially increased the amount of money spent on training, applying a structured training approach for the employees involved in NSD. Basic training is available to all firm employees via short periodical classes, while Green Belt and Black Belt certification programs involve a strict nomination and review process. The training program is administered internally and includes companywide a DSS education for practitioners. Any SSE employee can register for class and achieve basic Six Sigma certifications, named first White and then Yellow belt. Earned these certifications, employees have to be nominated and register for certification programs to continue learning. The following Six Sigma programs will take them through rigorous Green, Black and Master Black Belt certifications. These programs include intensive classroom education in Six Sigma tools and methodologies followed by projects participation.
For the future, the company is planning also to train part of the customer contact personnel on the service delivery procedures before the service launch, in order to improve the effectiveness of the delivery process.
Employees who are involved in NSD are qualified in process design and optimization. Whenever a Six Sigma project has been launched, a NSD team formed by Green and Black belts is formed. This NSD team must have high skills in using Six Sigma tools and techniques for quality improvement and process design.
Furthermore, SSE encourages the use of multifunctional teams i.e. teams which comprise experts from different functional areas. These areas should have good coordination and communication during the NSD process.
Finally, SSE has also developed leadership and change management classes. The final purpose is to extend its training to customers and suppliers so that the Six Sigma values might spread along the entire value chain.

Operational aspect

Typically, the application of Six Sigma for quality improvement of existing processes refers to the well-established DMAIC model. Contrary to this, DFSS does not have a unique model, and the literature on the topic offers several models, depending also on the characteristics of the process. Some of the most famous are the DMADV model (Define, Measure, Analyze, Design, Verify), the IDOV model (Identify, Design, Optimize, Validate) and the DMEDI model (Define, Measure, Explore, Develop, Implement).
The operational aspect is the third main aspect that SSE has considered in order to successfully implement DFSS to NSD. This aspect deals both to the implementation of the methodology in the company and the choice of the best tools to be used in the specific phases during a DFSS project.
SSE considered the use of formal procedures the basis for effectiveness in the activity of SSSD. The model that the firm has developed to implement DFSS to the process of NSD is the CDOV model.
The CDOV model (Concept, Design, Optimize, Verify) was created in SSE as a derivation from IDOV in 2005. Basically, the main difference consists in the major emphasis on the Concept phase, as the identification of a good service concept has a significant impact on the following service quality and customer satisfaction.
The *Concept Phase* is probably the most important among the four phases. It mainly refers to capturing the Voice of the Customer (VOC) in order to develop services that fit with their

needs. To perform this activity, the company makes extensive use both of survey researches and face to face interviews, using questionnaires. Here below this first phase is described in detail, in the case of face to face interviews. It is composed by a set of 9 steps:

1. Identify the SAM (Served/Serviceable Available Market), i.e. all the potential customers;
2. Comprehend the market strategy;
3. Identify the interview team;
4. Develop the questionnaire using KJ analysis, i.e. a tool for qualitative analysis;
5. Perform the interviews;
6. Translate the VOC in a process using a worksheet (define the service concept);
7. Send the statements on the service back to the customers (to validate and score);
8. Prioritize the customer needs;
9. Find the critical parameters for the service.

In the *Design Phase* the SSE's development team clearly defines a set of Critical to Quality factors (CTQ) for the service. Customer needs and inputs are carefully documented in order to successfully break down the service in sub-processes that can be provided without errors. This activity contributes to a high-quality design, improving service quality and customer satisfaction while the service is delivered.
In the *Optimize Phase* critical parameters are tracked and improved and the development team conducts a series of pre-launch tests to ensure success to the project before the actual launch. Both in the Design and in the Optimize phases, periodical reports are used in order to better monitor the situation.
Finally, in the *Verify Phase* the company conducts the post launch review and documentation after the new service launch. The post launch review could take a long time if the interface between service customer and service supplier is mainly human-based. In this case, indeed, although the process has been carefully designed, service providers could take additional time to learn the new procedures.
The purpose of SSE in this phase is finding a clear set of key performance indicators (KPI) to monitor the post launch performance of the service. More in general, another aim is seeking out appropriate performance measures to evaluate the effectiveness of NSD.
SSE, in order to hear the VOC and implement DFSS to its services, uses several tools and techniques. Project management tools and skills, for example, are widely used in the projects. Furthermore, management tools such as the balance scorecard are used and obviously the firm employs tools from quality management and statistics, like Pareto charts and regression. Actually, statistical techniques are not widely used in NSD Six Sigma projects and SSE prefers to use more qualitative tools like benchmarking, or even integrate tools from Lean Management.
The last part of this section represents in table 1 the classification of tools that SSE uses for DFSS projects. Each tool has been included in one or more phases, depending on those it is usually applied.

TOOLS		PHASES			
		Concept	*Design*	*Optimize*	*Verify*
1	Benchmarking		✓		
2	CTQ analysis	✓	✓		
3	DOE		✓	✓	
4	FMEA	✓	✓	✓	✓
5	Focus group	✓			
6	Internet focus group	✓			
7	Interview	✓			
8	Kano analysis		✓		
9	KJ analysis	✓			
10	Monte Carlo simulation	✓	✓	✓	
11	MSA		✓	✓	✓
12	Pareto analysis		✓		
13	Process mapping		✓		
14	Project management tools	✓	✓	✓	✓
15	Pugh matrix	✓			
16	QFD	✓			
17	Regression analysis		✓	✓	
18	Survey	✓			✓

Table 1: Classification of tools used in SSE.

DISCUSSION

In the previous sections it has been showed that the implementation of DFSS methodologies to NSD has meant considerable improvements within SSE, both regarding the financial benefits (e.g. service operational costs) and the customer satisfaction in the services. In summary, SSE has considered three main aspects in order to implement the methodology and obtain these results.

The strategic aspect is the first considered. In SSE, the Six Sigma projects selection represents the connection between business strategy and the needs of those customers who might receive the service that the company design. The statement of this link both has managerial importance, since it suggests a strategic view for Six Sigma methodology, and fills a gap in service literature. Goldstein *et al.* (2002), indeed, assert that literature on NSD has not successfully brought strategic service issues into service design. Some scholars have proposed concepts such as strategic project selection (Schroeder et al., 2008; Zhang et al.,

2008), claiming that is a process affecting the whole organization. However, these studies were general and not specifically focused on service design process in a company using DFSS methodologies.

As regards the organizational aspect, the remarkable importance of training has emerged in SSE. Bañuelas and Antony (2002) have formerly asserted that training is an important factor in the successful implementation of Six Sigma projects and SSE spends a conspicuous amount of money on this activity. Part of this money could be used to train some of the customer contact personnel on the service delivery procedures before the service launch, in order to improve the effectiveness of the delivery process. Besides to training, the importance of top management commitment has been confirmed, like in other Six Sigma studies (Schroeder *et al.*, 2008; Antony *et al.*, 2007), as well as the primary role of communication (Bañuelas and Antony, 2002). Furthermore, the use of experts from different functional areas in NSD teams has been highlighted as best practice by the firm for the implementation of the methodology.

Finally, exploring the operational aspect, it has been gathered that the post launch review and documentation (i.e. the Verify phase) tend to be longer in services rather than manufacturing. This issue could be explained quoting Antony *et al.* (2007), who assert that service processes in general are much more dependent on human and organizational change than manufacturing, hence, increasing the complexity of the whole project. Furthermore, during the application of the methodology, it has been highlighted the importance of the pre-launch test for NSD and the use of periodical reports as the project evolves. Lastly, SSE employs several tools in the CDOV model, e.g. quality and project management tools. However, even if Bañuelas and Antony (2002) claim that DFSS methodologies have strong bases in the use of statistics, statistical techniques are not widely used in NSD Six Sigma projects and more qualitative tools are preferred by project teams in the field of services.

To conclude this section, the main issues, procedures and best practices for the implementation of DFSS to NSD emerged in the SSE case study have been gathered and translated into statements. These statements, listed and grouped by strategic, organizational and operational aspect in table 2, could represent the basis for further in-depth studies on this topic.

ASPECTS		STATEMENTS
STRATEGIC	**1**	Use of formal procedures for NSD projects selection
	2	NSD projects prioritization based on objective factors
	3	Exhaustive risk analysis for the NSD projects
	4	The firm conducts periodical and detailed formal study of the market
	5	The firm clearly draws a set of customer needs and requirements before service design
	6	NSD projects selection is clearly linked to the corporate strategy
	7	Detailed financial analysis for the NSD projects

ORGANIZATIONAL	**1**	Top managers have long term commitment to NSD
	2	Strong support for NSD given by senior managements
	3	Structured training approach for employees involved in NSD
	4	Use of experts from different functional areas in NSD teams
	5	NSD teams skilled in using six sigma tools for quality improvement and process design
	6	Good communication and coordination among functional areas in NSD
	7	The firm trains some of the customer contact personnel on the service delivery procedures before the service launch
	8	The firm spends a conspicuous amount of money on training
	9	The firm extends its training to suppliers and customers
OPERATIONAL	**1**	Use of formal procedures in NSD
	2	Use of periodical reports during NSD
	3	The firm conducts a long post launch review and documentation after the new service launch
	4	Use of project management tools and skills
	5	The firm carefully collects customer needs and inputs during NSD
	6	Pre-launch tests for NSD before actual launch are performed
	7	Use of tools for the Voice of the Customer analysis
	8	The firm evaluates the effectiveness of NSD using reliable performance measures
	9	The firm monitors service performance using a clear set of Key Performance Indicators
	10	Use of balance scorecard and other management tools
	11	Greater use of qualitative tools rather than statistical and quantitative tools

Table 2: Statements for the implementation of DFSS to NSD.

CONCLUSIONS

The service sector plays an important role in all industrialized economies. In 2009 more than two-thirds of the GDP of almost all EU countries has been generated by this sector. However, despite its growing importance inferred by these data, gaps in service management literature are still widespread, when compared to manufacturing. As regards this, Chase at the 2004 Annual Meeting of the Decision Sciences Institute in Boston said that "80% of the United States' economy is in services, but 80% of the core or required courses in operations

management is still focused heavily, if not entirely, on manufacturing." (Heineke and Davis, 2007).
The field of NSD, scope of this research, is definitely suitable to further studies. In literature, there has been very little research specifically in this context. Moreover, existing research suggests that new services are mostly developed through unorganized and unsystematic processes and there are no generally accepted methodologies on this focus.
The Six Sigma methodology was born as a quality program in manufacturing more than twenty years ago. In the last decade the topic has also emerged in the academy and the literature on Six Sigma has steadily grown. Contributions refer to different management areas and activities, e.g. process improvement and NPD. However, despite several papers have investigated the impact of DFSS on product design, there is no empirical research on applications of this methodology to NSD process.
In this paper, an exploratory case study has been launched in an American lead telecommunications company that has applied DFSS to its services. The purpose has been to understand if the application of DFSS to NSD has a positive impact on performances and identify some best practices for the implementation of the methodology in this context. Empirical results have showed that its implementation has led to performances improvement, e.g. reduction of service operational costs and customer satisfaction enhancement. Furthermore, it has emerged that in order to obtain these benefits and successfully implement DFSS to NSD, the company has concentrated its efforts towards three main aspects:

1. The strategic aspect, dealing with the ability of the company to translate the best opportunity of improvement in a Six Sigma project whose purpose is connected both with customer needs and corporate strategy;
2. The organizational aspect, mainly dealing with the Six Sigma human resources employed in the company and with the training system adopted in the organization;
3. The operational aspect, dealing with the model that the company has implemented to apply DFSS to NSD (i.e. the CDOV model) and with the several tools used in this model (e.g. benchmarking and project management tools).

Empirical results emerged in the case study have been gathered and translated into statements, grouped by strategic, organizational and operational aspect. These findings are not general, obviously, but they could represent the basis for further in-depth studies on this topic. More case studies should be carried out in order to overcome the limitations of this study and addressing further developments both academic and managerial on this field. Service sector would benefit from these kind of studies, indeed, as they could support those companies whose NSD activities are unorganized and unsystematic, outlining procedures and best practices to improve their processes.
In summary, main results of this study have been twofold. By an academic point of view, since empirical research on DFSS applications in service processes is totally lacking, this study fills an important gap in scientific literature on Six Sigma. Furthermore, important managerial implications have been developed, explaining what are the critical success factors for Six Sigma organizations operating in this context and suggesting some best practices for the successful implementation of DFSS to services.

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