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Article Quality and Competitiveness: A Lean Six Sigma Approach

Amfiteatru Economic Journal

Provided in Cooperation with: The Bucharest University of Economic Studies

Suggested Citation: Dragulanescu, Irina-Virginia; Popescu, Delia (2015) : Quality and Competitiveness: A Lean Six Sigma Approach, Amfiteatru Economic Journal, ISSN 2247-9104, The Bucharest University of Economic Studies, Bucharest, Vol. 17, Iss. Special No. 9, pp. 1167-1182

This Version is available at: https://hdl.handle.net/10419/168973

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QUALITY AND COMPETITIVENESS: A LEAN SIX SIGMA APPROACH

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Please cite this article as:

Dragulanescu, I.V. and Popescu, D., 2015. Quality and Competitiveness: A Lean Six Sigma Approach. *Amfiteatru Economic*, 17 (Special No. 9), pp. 1167-1182

Abstract

Originally developed to improve the quality and production efficiency, Lean Six Sigma is now widely adopted in other non-manufacturing sectors such as financial, trade, services, etc. The methodology known as Lean Six Sigma combines the Six Sigma techniques, – which allow companies to reduce manufacturing defects – and the Lean Manufacturing principles, – which help companies benefit from faster processing for lower costs and with superior quality.

As a result of the research, the authors observed that, despite growing popularity and impressive outcomes obtained by some companies, the Lean Six Sigma model does not always offer the expected results.

However, the research has shown that the analysed company, operating in the field of courier services has managed to boost productivity and competitiveness by implementing measures that generated added value.

Keywords: Lean Six Sigma Model, waste reduction, DMAIC model, competitiveness, quality, Value Stream Mapping, Total Savings.

JEL Classification: L87, O14.

Introduction

Lean Six Sigma is increasingly more used as a methodological approach for an accurate sizing of a company's staff because: a) allows the objective assessment of inefficient processes; b) identifies the time and resource consuming activities, which do not add value and, simultaneously, enhances the quality levels of production processes. Practically, *Lean Six Sigma* is a hybrid methodology stemming both from the *Six Sigma model* developed by Motorola General Electric (Pande, Neuman and Cavanagh, 2000), whose prevailing concepts are performance and scientific management for reducing the defects of end products and the *Lean model (Lean Manufacturing)* elaborated by Toyota (Taiichi, 2004),

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whose main objectives are to be customer-oriented and to have a lean, flexible and fast management in order to decrease the lead time.

From the Six Sigma model, which is not a model that focuses on speed and on creating a company with a lean management structure, to the Lean model, which is not aimed at reducing the end product defects, nor the process errors is reached then to the Lean Six Sigma, whose main objectives are lean management, customer-orientation and obtaining performances, with the purpose of reducing defects (Lapre', Mukherjee and Wassenhove, 2000), errors as well as improving reaction times, by appropriately sizing the workforce and by exceeding the limits of the aforementioned original models.

1. The Lean Six Sigma international methodology

Lean Six Sigma is a methodology for process optimization that starts from the voice of the customer (VOC) and then identifies the most effective way to reach customer satisfaction, by reducing the variables in each stage of the process, in both the cases of production of goods, and supply of services.

By systematically reducing process variability, Lean Six Sigma simultaneously ensures the attainment of two strategic and apparently opposed company objectives: a) improving the quality of products and services and, concurrently, b) dramatically reducing the costs of production processes (losses). As a methodological approach (Aggogeri and Gentili, 2013), *Lean Six Sigma* is a disciplined and systematic method, based on statistical data and analyses.

The *Lean Six Sigma* methodological approach is increasingly more used in order for a company to perform an accurate workforce sizing because it allows:

• the objective assessment of inefficiencies;

• the identification of time and resource consuming activities, which do not add value simultaneously with enhancing the quality of production process.

Presently, *Lean Manufacturing* is the most important management method for manufacturing companies. Lean Manufacturing means efficient assembly cells or lines, a greater variety of interchangeable parts, which is mandatory for an excellent quality, reduced costs by enhancing the production process, international markets and global competition.

Lean Manufacturing or production for minimum costs represents a production philosophy that generates the decrease of time duration from the placement of customer's order to the delivery of product, by eliminating losses.

Thus, *Lean* (Lean Manufacturing), the American version of TPS (Toyota Production System) is the system that focuses to the loss reduction. In recent years the name of this system has been slightly changed becoming *Lean Six Sigma* which also includes the reducing of variability. Other systems include also the *Agile* term (supple) with reference to how and the speed with which the company responds to changing market demands.

The *Lean Manufacturing* concept is based on a series of techniques and principles, some of which exclusively refer to the production department, while others focus on several functions of the company, which are:

• Kaizen - in Japanese, kaizen means continuous improvement.

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• Waiting time: 0

• *Kanban/Pull-type production* - communication tool in the Just in Time system (JIT). Kanban is an index card attached to a certain number of products or parts on the production line, which gives delivery instructions for a certain quantity. Practically, Kanban becomes an order for the production of a new batch.

• Inventory 0;

• *Jidhoka* - device that turns the machine off every time a reject is produced. This device is the key for introducing JIT.

• *The circuit of a single part* - in a JIT production system, only a single part is allowed to circulate from one process to another in order to mitigate the losses.

• *Visual management* - allows the seizing and signalling the attainment of conditions that can generate the occurrence of an abnormal situation, so that it may be possible to apply corrective measures in real time.

Examples of abnormalities: an operator who does not comply with the work instructions, continuous regulation of a piece of machinery, an order form lying on the floor, products not delivered on time at the downstream station, a container left in an unidentified space, lack of cleanliness, too much stock at a working station, an operator sorting parts before processing or being idle, etc.

• *Standardized work* - is an optimal combination between man, machine and materials. The three elements of standardized work are:

takt-time (is the time in which the production line should deliver one unit on a constant basis in order to achieve the order placed by the customer within a specified time frame)

- work operation;

- intermediate stock being processed.

Lead-Time represents the total time counting from the entry of raw materials in the production process and ending when the product is finished and ready to be delivered to the customer.

In the services industry, the total time starts the moment when the customer expresses his/her need and ends the moment when this need is satisfied.

Within the Lean Six Sigma approach, the interesting fact is the *takt time*, the necessary time to produce a part of a product ordered by the customer - the ratio between the total production time and the number of parts that must be produced.

• *Muda* - Japanese word meaning "loss"/"waste". Muda represents one of the three M's, the others being Mura - irregularity and Muri - illogical. Consequently, to determine and control the desired level of performances for the processes within a company means to clearly identify the types of activities performed, which are:

- Activities that add value - which, from the customer's point of view render a product/service more valuable;

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- Activities that add value - which, from the customer's point of view render a product/service more valuable; but from the supplier's point of view, not all activities that do not add value for the customer can be completely eliminated. The latter can be categorized as: activities that do not add value, but are indispensable and activities that do not add value and that are necessary.

The implementation of the Lean principles has become a survival strategy in a production environment where cost-cutting represents the current state of affairs on the market. Lean is a subject based on five key principles:

- Value setting an accurate value of the product/service having the customer in mind.
- Value Stream identifies the Value Stream and eliminates all waste.
- *Flow* manufactures the product as smoothly as possible.
- *Pull* produce only as much as the customer orders.
- Perfection (Kaizen) eliminating waste as a continuous process towards perfection.

The *lean* technique is aimed at eliminating waste in all areas of the production process, customer relations, product development, supplier networks, but also related to company management. The main objective of the *lean* technique is connected to minimizing the human effort, inventory, time necessary for the development of new products in order to be able to cope with the demands of the various customers, achieving high-end products in the most efficient and economical way possible. In order to create a "lean company", it is necessary that all members of the organization work hard and show perseverance, because this technique does not offer immediate results, but reliable long-term results.

By applying the Lean Six Sigma methodology, in the context of a company in the field of services, a branch office of TNT Italy, on the basis of statistics and with the contribution of the field expert Charrey - by systematically reducing the process variability, it was possible to attain two strategic, apparently opposed objectives: a) enhancing the quality levels of products and services offered and, simultaneously, b) significant cost (waste) reduction at the process level.

2. Quality and productivity

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Therefore, Muda is a technical term within industrial production, which is translated as "waste" and it is one of the three M's, which should be avoided: *muda* meaning losses, rejects, defects, waste, in total seven such wastes; *mura* (irregularities, disruptions) and *muri* (overburden, tedious or delayed activities). Generally, the seven types of wastes stated in the Lean theory are:

- resource consuming activities, which do not add value
- · mistakes that must be corrected
- · products or services performed without being demanded by someone
- futile operations included in the work processes
- futile movement of materials and people

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• unused available capacity - waiting for someone or something when someone asked for something

• products or services incompliant with the customer's requirements.

Waste occurs as a consequence of the traditional production system, within which many flawed parts result. Only the implementation of a Six Sigma quality system can prevent the production of flawed parts and avoid them being sent to subsequent processing phases within the technological chain. Generally, there are two types of activities being performed at the workplace: activities that add value and activities that do not add value. Therefore, *Muda* can be categorized as *Type 1 Muda*, which are aimed at all the activities that do not directly add value to the product, but which are necessary to the performance of the activities that do add value, which are related to quality control, human resources, accounting, housekeeping, workshop, technical assistance, maintenance, etc. The other category, *Type 2 Muda*, namely the seven wastes (Figure no. 1) includes those operations that can be immediately eliminated, without creating problems for the other activities.



Figure no. 1: The seven types of *muda* or activities that do not add value

Types of muda or activities that do not add value are:

• *The muda of overproduction* occurs when there is more production than necessary and, as a result, this generates losses through the raw material consumption, as well as through the storage of the overproduction.

• *The muda of motion* refers to the movements of a person's body which do not add value. For example, when the person walks he/she does not add value. In order to identify the *muda of motion*, one should study the additional movements, which are not necessary. And, consequently, everything must be rearranged and reorganized in order to eliminate the additional movements.

• *The muda of waiting* occurs when an order is launched and its processing generates a long waiting time, this being an activity that does not add value.

• *The muda of transportation,* which represents an important part of operations, but simply moving and rearranging bring no value whatsoever.

The following table presents several examples of Muda-type activities, some generated within the production and other processes that are a part of the office activities (Table no. 1).

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MUDA	Examples related	Examples related		
	to the production process	to the office activities		
Overproduction It is generated when there is an excess in production, but it is also caused by storage of raw materials, of semi-manufactured products, etc., for a certain period of time. This not only includes the stock of products stored in the warehouse, but also the parts of the production flow that are in between two phases of the production process (work in process - WIP).	Parts, components and accessories from the storage stock, finished parts, which have not been ordered; excessive safety stocks, queues of raw materials / materials in between operations.	Stationery, office supplies, unused machinery; unprocessed invoices; orders pending to be launched in the production process, etc.		
Motion	Excessive movement between	Going from the desk to the		
Futile motion that does not add	two working stations; non-	photocopier. Looking for a		
too slow, or in different paces	a part during the assembly time.	desk. Finding documents that		
between operators.	a part daring the assertery time.	were supposed to be at hand.		
Defectiveness = inconformity /	Reprocessing; replacing	Correcting errors in		
lack of quality	defective products before	documents; archiving		
Waste related to the non-quality	shipping or before being	documents in the wrong		
customer complaints and repairs	defective raw materials or semi	regarding the service		
customer complaints and repairs	manufactured Producing large	rendered: errors caused by		
	quantities of defective parts	misinformation or		
	instead of identifying the	inaccuracies.		
	problem after one or two			
	defective parts; costs generated			
	by managing customers'			
Transportation	Complaints	Moving documents from one		
General losses in the phase of	areas before being successively	place to another moving the		
moving, transferring.	processed: handling parts from	stationery to a remote storage		
lifting/lowering, stacking, or	different containers before	area.		
moving the parts needlessly. The	fitting them, unavailability of			
losses can also be generated by	tools in the kit, long			
problems related to transportation	conveyance distances caused by			
distances, flows and speed.	the unsatisfactory position of			
Process-related waste	Performing controls upon entry	Requesting approval		
"Futile activities and operations.	when a supplier already	signatures from several		
which are traditionally considered	guarantees defect-free products;	persons whose authorization		
necessary"	performing process stages that	is redundant. Collection of		
	have become pointless as a	data that is not used or that		
	consequence of changes made	nobody looks at: requesting		
	to the product or the process.	useless or double data		
	thermal treatment) which are	instead of using text		
	not justified from a technical	processing: performing		
	point of view.	photocopies of a document.		
	-	when a storage file is		
		sufficient.		

Table no.1: Muda generated within the production processes and office activitie	Table no.1: Muda	generated within	the production	processes and	office activitie
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The following table presents several examples of Muda-generating activities, generated within the production processes as well as in the field of services (Table no. 2).

Table no. 2: Muda generated within the production processes vs. the services field

in p	production	in t	the case of services
1.	there is overproduction	1.	pointless repeated controls, the repeated
2.	there are redundant processes that		performance of the same task by two people
	do not add value		who do not communicate with each other.
3.	there are excessive stocks	2.	unstandardised working procedures,
4.	pointless motions are made, caused		disorganisation, frequent change in priorities
	by the inappropriate placement of	3.	gathering and using pointless materials and
	working stations and non-		information - irrelevant, redundant or outdated
	ergonomic equipment	4.	idleness and resistance to change (the "This is
5.	a product is repeatedly relocated for		how we have always done it!" syndrome)
	successive operations	5.	not using the accumulated knowledge - lack of
6.	there are waiting times, necessary		communication, not expanding the solutions for
	resources unavailable when needed,		improvement that work in practice, lack of a
	uncompleted production in the flow		framework to capitalise upon the implicit
7.	the customer (either internal, or		knowledge
	external) receives non-complying	6.	waiting time caused by overly complex
	products.		procedures, delays generated by pointless
			discussions, unclear levels of responsibility and
			inappropriate delegation
		7.	intuitive decision-making, without performing
			an analysis of the available data and of the
			possible consequences

After having identified Muda, the next step is to assess the need for intervention in order to improve the quality, to increase productivity, to reduce stocks and the WIP (*work in process* - technical term which indicates the number of units or batches, which are processed simultaneously in a production system; it refers to the material in between two processing stages), to shorten the production lines, to reduce set-up lost time, to reduce spaces, to reduce the duration of the production processes.

Table no. 3 indicates several concepts without Muda, which can be adopted by ensuring the ideal working conditions, but to which technical and design type measures can be added.

Table no. 3: Several basic concepts of Muda

Worker	Producer	Materials	Methods
without looking	compact, not cut to shape	no bolts and nuts	no blockage
without moving	no strips	no burrs	no large batches
without searching	no set-up	no waiting time	no storage
without stopping	no pressers	no stock	

3. "Gemba" analysis for the improvement of productivity

3.1 "Gemba" analysis within production processes

It is also important to intervene even with respect to recovering minimum times, in case the operations are repetitive. Intercepting wastes can start anywhere, even with recovery of minimum times. By minimum times we refer to those times that can be recovered through

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on-site analysis ("Gemba" in Japanese) of operations performed by workers, while they are working. We must take into account the fact that there are two types of minimum times, and, consequently, we must treat the two categories differently:

• Lost time for operations that are not necessary during the production stages

• Lost time because of "pointless walks", meaning time the staff wastes looking for materials that are not in their designated place, of equipment that must be available, of lifting devices that are being used by other workers.

The difference between the two is apparent at least with respect to size: slow rotation of a screwdriver may end up consuming many minutes at the end of the working day, while waiting for an unavailable forklift or crane, looking for a missing tool, may cost at least one hour/day (in case the "pointless walks" in search of the missing tool is not extended later by having a cup of coffee and a conversation about the last football match, what the children are up to, and so on. The Gemba analysis is meant to reduce lost time, therefore it should start not by timing actions and methods, but by observing lost time caused by excessive organisational errors. Besides, organisational problems can vary. For example, how can it be possible for a great Italian company that is a global leader in its field (to which many companies strive for globally), only has a single forklift catering for one of its departments with a staff of 57 to transport the products, out of which none can be lifted manually, between one stage to another of the production cycle? A 5 t forklift costs around €6,000 -7,000 and an HPT (hand pallet truck) costs under € 700; if we multiply 30 minutes time lost waiting for the forklift per every person per day, with the cost for 57 full-time workers this is enough to purchase two hand pallet trucks per day and a forklift truck in less than one week. But since seeing does not always mean noticing, it would be interesting to take other aspects into account related to the following:

• material handling methods

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• through a covert verification to identify the period in which the crane (if it exists) remains inactive during the half an hour of observation; repeating the observation for a period of several days can lead to the collection of accurate statistics (in case the crane works continuously, then this means that there should be a later investigation consisting of a systematic observation and/or observe how many inactive people are waiting for the crane) - a serious analysis of the data can represent a tool that can be at the basis of the opportunity to acquire an asset

• the workers' "pointless walks" times, which refer to the time a worker spends away from the workplace in order to go recover tools, materials, information from the boss, etc. Additionally, the assessment of the percentages represented by this period of time in the total 30 minutes of work observed constitutes another important element.

• time for the modification of the equipment / technological lines format.

Besides the aforementioned, it should be clearly ensued that in order for a workshop to introduce the lean production, it must adopt the *quick change over (QCO) strategy*, analysis which is aimed at a technological upgrade and quick change of production leading to a greater *manufacturing flexibility*. Reducing the times for the changeover of the production format enhances its programming system towards Heijunka, which presupposes the division of the minimum production batch, which, in its turn, is imposed by the "obligation" of





producing a large number of parts (and, therefore, to massively increase the *work in process* - *WIP*), because, generally, the time for changing the cast (which may take hours) cannot be compensated if only a few parts are executed, therefore it is "convenient" to produce a huge amount of parts, in order to have stock, thus decreasing the cost per part. This statement is still pronounced too often. But, the principles of lean production, more specifically lean thinking, state that it is highly important to analyse the time wasted, because it is common knowledge that a company's competitiveness starts from the individuation of lost times (both maximum and minimum). Besides the change in format that offered the most possibilities for savings, more specifically to transform the organisation into a lean one, the analysis of the lost times, which should not be used to lay off the lazy worker, can supply the following important information:

• how can the equipment and machinery layout be changed in order to avoid people and materials having to go on superfluous routes

• individuation of dangerous flow junctions for the safety of workers: to avoid hurting and injuring people with the forklift in transit by relocating the storage areas

• assessment of the non-compliant character of the technical equipment: besides the handling and transportation problems, we should also emphasize that presently a calibre costs around \notin 45 and a screwdriver or some tongs cost much less than that. A worker walking in the workshop to get some tongs or a calibre from his colleagues costs much more than the price of the tools.

• another phenomenon that creates minimum, but constant time losses is the breakdown of tools (e.g. one of the pneumatic or electric power tools that are found by the hundreds in a plant); the worker does not communicate that a piece of equipment has failed, except for when that worker needs to use it and he either goes to get it fixed or - more frequently - he goes to borrow it from one of his colleagues, who will most definitely protest and waste more time trying to prevent him from taking his tool (as it is common knowledge, workers are jealous of their colleagues' tools)

• in addition, other negative reasons for these pointless walks through the workshop arise, others than the ones mainly related to the working tools (tongs, calibre, etc.). For example, the workshop manager is not privy to the technical information in order to communicate it to the worker, nor to the technical drawings, number of cycles, detailed working instructions, or even worse, the customer's specifications included in the contract. In this case, there needs to be an investigation on the organisational shortcomings and it should not be taken lightly. Consequently, there is a need for action in all directions and even to leave aside all concerns regarding the inefficiencies Quality Management Managers emphasize in a well-executed documentation.

Therefore, in the authors' view, the only paragraph of the ISO 9001:2008 standard (the revision of the standard is scheduled for approval in September 2015), which must be the main objective that an entrepreneur should especially strive to firmly comply with is paragraph 8.5 (currently in force).

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3.2. Gemba" analysis within the provision of services

The next part of this article will deal with the analysis and quantification of the lost times during flight on an airplane. The premise is that travelling is an interesting experience in itself, but sometimes it may be a tedious one as well. Generally, air-travel tickets are sold for high prices, but what added value are we truly buying? (table no. 4)

Table no. 4: Detailed list of actions during a flight

1.	Going to a travel agency to purchase tickets	16.	Waiting in the aircraft for the permission
	(30 min d/i), although nowadays more and		to take-off (congested traffic = 20 min)
	more people buy them online	17.	Transfer of aircraft to the take-off
2.	Waiting for the ticketing / travel agent (15 min)		runway (15 min)
3.	Calling a taxi	18.	Flight to destination (3 h)
4.	Waiting for the taxi (15 min)	19.	Waiting inside the aircraft (stopping and
5.	Loading the luggage in the taxi		disembarking) (25 min)
6.	Going to the airport (1.5 h), before the	20.	Passport control queue (20 min)
	departure time (2 h)	21.	Waiting for the hold luggage (25 min)
7.	Unloading luggage from the taxi and	22.	Luggage/customs control queue
	walking to the check-in gate		(15 min)
8.	Check-in queue (25 min)	23.	Taking the luggage to the taxi-designated
9.	Security check queue (30 min)		area
10.	Passport control queue (15 min)	24.	Waiting for the taxi (20 min)
11.	Boarding terminal queue (20 min)	25.	Loading the luggage in the taxi
12.	Getting on the bus for transfer	26.	Taxi ride to the hotel (30 min)
13.	Waiting in the bus so that all passengers get	27.	Unloading luggage from the taxi
	on (30 min)	28.	Waiting to check into the hotel (15 min)
14.	Transfer to the air stair	29.	Going up to the room
15.	Boarding all passengers (20 min)	30.	End of exhausting trip

Total process time = 12.5 hours

Time with added value = 3 hours (30%)

Time without added value = 9.5 hours

Time spent waiting and in a queue = 4.5 hours (47%)

No. of queues = 10

No. of times handling the luggage = 7

In a nutshell, one can notice how a trip from one destination to another involves activities that add value, times that do not add value and waiting times. It is to be noted that the times without added value represent 70 % of the total process time, which entails that actions must be taken for their decrease.

4. The Lean Six Sigma: key study

The Lean Six Sigma methodology has been applied by a company in the field of courier services, which is a global leader on the market, called TNT Express Italy - the Milan branch.

The activities related to the operation of parcels are complex, therefore, after generating the parcel listed in the outgoing or transfer documents, the parcel must be taken over by the operators who package the products and prepare the accompanying documents.

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Thusly, the parcel can include the following information:

• The partner to whom the parcel is being shipped can be a Customer, a Subunit or Management is automatically filled in from the source document and this cannot be altered;

• The courier who will transport the parcel (this is automatically filled in with the information from the first document in the parcel, but it can be changed later);

• Total Mass and Volume of the parcel calculated depending on the mass and volume of the products inside the parcel;

• The people responsible for the accuracy of collecting and packaging the products ("Collector" and "Checker") and the dates when these operations are to be completed;

- Parcel identifier;
- Number of packages in the parcel.

The DMAIC cycle is a model for the continuous enhancement of quality. As a structured approach, the DMAIC model (Define-Measure-Analyze-Improve-Control) (Table no. 5) can provide a business with a series of solutions. Practically, this model helps companies solve their problems from the beginning to the end simultaneously with achieving fundamental results (Table no.6).

For the elaboration of this paper, the authors have used the DMAIC model to assess the courier activities, in accordance with the theorization of the Lean Sigma Institute.

Stages	Define	Measure	Analyse	Improve	Control
Activities	Defining	Identifying	Analysis of	Identifying	Controlling the
	the current	the possible	the possible	possible	efficiency over
	situation	causes	causes	solutions	time
	↓ ↓	↓ ↓	\downarrow	↓	↓
	Defining	Quantifying	Selecting the	Selecting/imple	Implementing
	the desired	the problem	initial causes	menting	control
	situation			solutions	measures
Results	Defining the	Source of the	Quantified	Pilot solutions	Control
	problem	problem and	causes and	and permanent	and monitoring
	Possible	list of causes	initial causes	implementation	of processes
	benefits		selected		Confirmed
					benefits

Table no. 5: The DMAIC model

 Table no. 6: Focus on Lean - Reducing waste and improvement of working flows by involving the staff

Focus	Elimination of activities without added value for the customer
Process	Creation of process flows in order to reduce the variability
Teamwork	Collaboration with the subordinates
Sustainability	Implementation of the continuous improvement culture
Local Level	Simple solutions devised by local teams
Intelligence	Working in a more intelligent manner instead of working harder

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The DMAIC model was used in order to define the field of application.

The process taken into account presupposes the operation and delivery of parcels: unloading activities, recording incoming/outgoing data and labelling the parcels meant for shipping, synthesized in the figure below (Figure no. 2).

Process	Take-over and	Placement on the	Data	Labelling
	snipping of	conveyor belt	entry	

rigure no. 2. rrocess mapping	Figure	no.	2:	Process	Mapping
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Included data: All the parcels and envelopes with national destination that are meant to be shipped (collection and delivery - via agents/proxy)

Excluded data: Management of international shipments and of internal parcels managed as being in consignment (services meant for large customers)

Defining the problem of the "Outgoing" Process

current	- The operational efficiency related to the labelling process of the
situation	outgoing parcels that are picked-up by collection agents is presently
	insufficient - a level of productivity of approximately 300 parcels/hour.
	- This inefficiency might have an impact on the hourly planning, thus
	generating delays in starting-up the lines
	- All this results in a delayed completion of delivery operations, which
	occurs a little sooner than 10:00pm.
desired	Improvement of the operational flow related to the delivery parcels, in
situation	order to be able to complete the activities no later than 9:30pm.

Desired benefits for the process, which were anticipated in the project:

 Completing the delivery operations no later than 9:30pm, with an advance of a half an hour compared to the current situation

• A decrease of minimum 10 working hours for handling operations

The analysis stage revealed the causes for errors (Figure no. 3):

• The processing of documents is performed in accordance with LIFO (stands for lastin, first-out) and the processing of the parcel-loaded pallets is performed in accordance with FIFO (first-in first-out)

• Non-value adding activities between a process of selection and registration and another type of process (fax, photocopier, etc.)

• Processing 2 documents simultaneously, the second one having longer waiting times

• Waiting time for unloading the platform caused by the delay with which parcel no. 1 arrives at the Totem in its turn caused by the verification of the data entry into the system

• Unloading the parcels (incoming and delivery) on two sides of the warehouse did not allow the optimisation of workload and time

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Figure no. 3: Value Stream Mapping Source: own elaboration on the basis of Storch, 2010; TNT Italy, 2012

• Lack of planning related to labelling, depending on the starting time and order of the parcel unloading off the conveyor belt

- Excessive handling of so-called *special* parcels (before and after labelling)
- Data entry freeze-up caused by the resource deficit

• Some parcels were falling off the conveyor belt, thus blocking the flow and then the process.

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The following solutions have been identified in the **Improve** stage:

- Maintaining the parcel processing depending on the order of arrival (FIFO)
- Processing the parcel accompanying documents individually and not simultaneously

• Non-value adding activities are to be delayed after the completion of data entry into the system

 \bullet loading the parcels on the conveyor belt by preserving the order of arrival at the branch office

- performing the unloading on a single side of the warehouse
- anticipation of the labelling activity: 1st at 5:30pm and 2nd at 7:00pm
- · parcel labelling is to be performed according to the position order and data entry

• applying a side protection on the conveyor belt in order to prevent parcels from falling and blocking the next batch

In the next step, by using Value Stream Mapping (VSM) (an advanced technique of management operational), that connects the information flow and material flow can be identified the wastes existing within business system based on Lean Thinking of courier company analyzed.

The goal of the Control phase is to check if the results were attained (Table no.7).

Management group	Subunits	Critical to Quality CTQ	Specifications	Measuring Method	Sample size	Frequency	Who performs the measurement	Where is it recorded
Return to headquarters Collecting agents	Unloading parcels	Recording the return schedule	Until 8:00pm hours	The person records in a form the number of round trips and the return to HQ schedule of collecting agents who return after 8:00pm	All delayed collecting agents	On a daily basis	The dispatcher based on logbooks	Specific Excel spread sheet
Deliveries	Outgoing	No. of parcels that are processed internal deliveries	Does not apply	Analysis of branch statistics (Check-in source)	Analysis of the entire activity	On a daily basis	Departures Co-ordinator	Specific Excel spread sheet (control plan)
Deliveries	Data entry	No. Managed shipping	Does not apply	Analysis of branch statistics (Check-in source)	Analysis of the entire activity	On a daily basis	Departures Co-ordinator	Specific Excel spread sheet (control plan)
Deliveries	Labelling	Starting and completion schedule per each totem	Large customers (4:30 - 8:30) pm 1st Totem (5:30 - 8:30) pm 2 nd Totem (7:00 - 8:30) pm	Manual entry of the starting and completion time for each management group (Totem)	All inventories are analysed	On a daily basis	Inspector of the Deliveries Warehouse	Specific Excel spread sheet

 Table no. 7: Results obtained in the Control phase

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The content of the Control Plan and characteristics of elements under assessment are essential for:

- Verifying the appropriate achievement of project goals
- Process monitoring

The results obtained as a consequence of applying the model can be summarised as follows (Table no. 8).

No.	Before the project	After the project	
Productivity in generating documents (invoices, notices to subunits or transfer delivery notes) D.E. x h	900	1,318	
Productivity in generating documents D.E./person	160	219	
Labelling Productivity x h	300	540	
Schedule of activity completion	10:00pm	9:27pm	
Recirculation of parcel x h: %	> 50%	1%	
Recirculation of parcel x h: number	> 400	9	
No. Amount of hours days	133	- 117.5	
Saving hours days	0	15.5	

 Table no. 8: Findings from applying the DMAIC model

Saved hours (15.5 hours/dd x € 12.5/hour x 250 working days)	→€48,438.00
Reduction of undelivered parcels	
(10 parcels/day x €20/parcel x 250 working days)	→€ 50,000.00

TOTAL Savings $\rightarrow \notin 98,438.00$

According to value stream map explanation were identified value-creating activities, and wastes (*muda*) activities that do not create value. There was an improvement in the completion schedule of the activities of collection / delivery, registration and labelling of parcels from 10 p.m. to 9:27 p.m. hours, achieving a reduction 33minute / day.

Also concerning the productivity in generating documents per hour, it improves with 46.44%, productivity in generating documents per person with 36.87%, with 80% Labelling Productivity x h.

Thus, by implementing the project annually saves 98,438 Euro, of which 48.438 Euro concerns the value of the total hours saved and 50,000 Euro representing the value determined by reducing the number of undelivered parcels.

Conclusions

Lean Six Sigma surpasses the fordist concept of organising the plant vertically with an integrated horizontal concept based on processes and not on functions. This type of organisation represents the creation of a quality culture, which have a positive impact on the product or the service The introduction of automation and digitalisation has brought a substantial contribution to the Lean Six Sigma system in the sense of performing process

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control, eliminating waste and defects, in order to satisfy the customer's demand as a user of products or services, with the goal of ensuring the customer's total satisfaction.

The working method consisted of analysing the organisation of the services company and, on the basis of the (mathematical and statistical) studies in this field, an assessment of the current level of process performance has been carried out.

Therefore, the research has emphasised organisational shortcomings within the company structure caused by repetitive processes, non-value adding activities, lack of planning the activities in the various stages of the production process. Some solutions have been identified for these shortcomings in order to better respond to customers' demand, to increase the efficiency of the company, benefitting competitiveness in a global market. Therefore, the recommendations proposed, including improvements and solutions, compared to the imposed standards prove the validity of the Lean Six Sigma project implemented.

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