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## Managerial accounting solutions: Lean Six Sigma application in the woodworking industry. A Practical aspect

**Abstract.** The increasing complexity of business relations in the conditions of increased competition, manifested in the process of allocation and use of economic resources as well as in the process of seizing the outlets, has led to a profound revolution in the field of both management and accounting as the main source of information, being of a significant use in the decision-making process. The configuration and complexity of the functional, technical and organisational structure of economic entities, including the variety of carried out activities and the continuous introduction of advanced technologies, are the factors that assert managerial accounting as an essential component of the accounting system. In this context, entities are constrained to a rational use of the factors of production in which the consumed resources are minimised and the benefits are maximised. In today's global context, organisations are trying to find optimal solutions to deliver products or services that add new value, satisfying customer requirements at low cost and high quality. These issues can be answered by various methods, including Kaizen (part of Lean Manufacturing), 5Why, Six Sigma, etc. Kaizen is a Japanese word that means Continuous Enhancement. 5 Whys is a technique used in the Analyse phase of the Six Sigma DMAIC (Define, Measure, Analyse, Improve, Control) methodology. It is the great Six Sigma tool that does not involve data segmentation, hypothesis testing, regression or other advanced statistical tools, and in many cases can be completed without a data collection plan. The concepts and methods to be presented in the paper provide solutions based on complex evaluation and reporting systems. At the same time, the paper also includes some of the experience gained in the process of analysing the activity of a company operating in the woodworking industry. Lean Six Sigma can be used with maximum efficiency by woodworking firms. This enables them to achieve superior sustainable performance. The Lean Six Sigma techniques, among others, improves and accelerates processes, reducing scrap and intermediate stocks. Implemented correctly and continuously, Lean Six Sigma leads to visible improvements in the financial results.

**Keywords:** Six Sigma; DMAIC; Accounting; Manufacturing; Woodworking Industry; Information Technology; Costs

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**Рішення управлінського обліку: використання технологій Six Sigma в деревообробній промисловості. Прикладний аспект**

**Анотація.** Зростаюча складність ділових відносин в умовах загострення конкуренції, що виникає як у процесі розподілу й використання економічних ресурсів, так і захоплення торгових точок, стала рушієм у галузі управління та опосередковано в бухгалтерському обліку. Конфігурація та складність функціональної і техніко-організаційної структур господарюючих суб'єктів, різноманітність діяльності й постійне впровадження передових технологій є факторами, які роблять управлінський облік найважливішим компонентом системи бухгалтерського обліку. У цьому контексті компанії обмежені раціональним використанням факторів виробництва, за яких ресурси мінімізуються, а доходи максимізуються. Підприємства намагаються знайти оптимальні рішення стосовно виробництва продукції або послуг, які створюють нову цінність, що задовольняє вимоги клієнтів щодо низьких витрат і високої якості. На ці виклики можна відповісти різними способами, включаючи Kaizen (частина Lean Manufacturing), 5Whys, Six Sigma тощо. «Kaizen» означає «безперервне вдосконалення», 5 Whys - метод, який використовується у фазі «Аналіз» Six Sigma DMAIC. Це відмінний інструмент Six Sigma, який не включає в себе сегментацію даних, перевірку гіпотез, регресію або інші передові статистичні інструменти, і в багатьох випадках його можна виконати без плану збору даних. Поняття та методи, які будуть представлені у статті, здатні забезпечити рішення на основі складних систем оцінки та звітності. Водночас у статті також міститься досвід, отриманий у процесі аналізу діяльності компаній деревообробної промисловості.

**Ключові слова:** Six Sigma; DMAIC; управлінський облік; бухгалтерський облік; інформаційні технології; виробництво; витрати; деревообробна промисловість.

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**Решения управленческого учета: применение технологий Six Sigma в деревообрабатывающей промышленности. Прикладной аспект**

**Аннотация.** Растущая сложность деловых отношений в условиях обострения конкуренции, проявляющаяся как в процессе распределения и использования экономических ресурсов, так и захвата торговых точек, привела к революции в области управления и косвенно в бухгалтерском учете. Конфигурация и сложность функциональной и технико-организационной структуры хозяйствующих субъектов, разнообразие осуществляемой деятельности и постоянное внедрение передовых технологий являются факторами, утверждающими управленческий учет в качестве важнейшего компонента системы бухгалтерского учета. В данном контексте компании ограничены рациональным использованием факторов производства, когда потребляемые ресурсы минимизируются, а выгоды максимизируются. В сегодняшнем глобальном контексте организации пытаются найти оптимальные решения для предоставления продуктов или услуг, которые добавляют новую ценность, удовлетворяя требования клиентов касательно низких затрат и высокого качества. На данные вызовы можно ответить различными способами, включая Kaizen (часть Lean Manufacturing), 5Whys, Six Sigma и т.п. 5 Whys – метод, используемый на этапе анализа методологии Six Sigma DMAIC. Это отличный инструмент Six Sigma, который не включает в себя сегментацию данных, проверку гипотез, регрессию или другие расширенные статистические инструменты; во многих случаях его можно выполнить без плана сбора данных. Концепции и методы, представленные в статье, представляют решения, основанные на сложных системах оценки и отчетности. В то же время в статье также содержится опыт, накопленный в процессе анализа деятельности компании, работающей в деревообрабатывающей промышленности.

**Ключевые слова:** Six Sigma; DMAIC; управленческий учет; бухгалтерский учет; информационные технологии; производство; расходы; деревообрабатывающая промышленность.

## 1. Introduction

Small and medium-sized enterprises in almost all EU countries constitute inexhaustible wealth, both in terms of knowledge that is concentrated in the work of artisans and specialised operators, and on the opportunities for growth and economic development.

However, the current economic and financial situation has forced many of these companies to «lose their ground» or even withdraw from the market. Competition is fierce and the economic survival under such realities usually depends on the ability to create and maintain a delicate balance between the quality and uniqueness of the offered product. The uniqueness and the internal efficiency distinguish this kind of businesses from industrial production.

Almost all handicraft companies emerge in the manufacturing field and therefore base their own success on the ability to produce something unique and economically sustainable. If the issues of administrative and accounting management can be standardised on the basis of deadlines, regulations and legislative requirements, then it is possible to make a difference in the production process by creating a basis for survival and success on the market.

According to a study by PwC Romania, it is important to underline that the direct contribution of the wood industry to the formation of GDP in Romania has been relatively constant over the last decade, ranging between 1.1% and 1.5%. From this point of view, Romania was ranked 9<sup>th</sup> in 2014 within the European Union (1.1% compared to the EU average of 0.4%). According to a press release, if the indirect and induced effect on the economy is considered, Romania's forestry and wood processing industry contributes 3.5% to GDP (PWC, 2015). However, the forestry sector and the wood industry in Romania were in the challenging position in the 2013-2018 period in the sense that costly control systems has been implemented, the illegal cuts had been significantly reduced, and the wood industry had evolved. Unfortunately, overregulation that hampers the legal use of resources (wood) has remained unchanged. The transition from reducing the illegal cuts to investment and increasing the volume of legal exploitation has not been achieved yet. Fordaq statistics also show that the small business segment was the most affected, both in the operating sector and in the primary processing and furniture industries.

«More than 1,800 small businesses in the mining sector, more than 2,800 of the primary wood-working and over 500 of the furniture industry have arrived with their own capital in the negative area, practically most of them will be in a state of incapacity to pay and they will cease activity. The worst crisis is in the wood exploitation sector, where the disappearance of small businesses makes it increasingly difficult to mobilize the resource from small forestry properties» (Financial Magazine, 2017).

Any entity aims to produce and distribute the goods at acceptable prices while being attentive to any competitive pressure that has arisen. The question is not only how to introduce the necessary changes in a way to streamline processes but also how to implement a mechanism that encourages direct participation of the whole labour force. A firm will always want to meet competitive criteria with better machinery or a modern design of products. Unfortunately, these advantages are not long-lasting.

The disadvantage of classical systems is that they are aimed at producing large quantities of products. Over the life of such systems, they are increasingly influenced by bigger and sophisticated storage, new handling systems, increasingly complex production lines, all of which are implemented to respond any problem that arises. Another problem is the cost of labour. The use of such complex systems brings an increase in expectations regarding remuneration.

## 2. Brief Literature Review

«Achieving an efficient, flexible and high quality production process is an inevitable challenge for each production company. This requires a well-established strategy, the identification of explicit objectives for the productive function and focused actions to achieve these objectives» (Cagliano & Spina, 2000).

One of the most common challenges for those who need to manage a small entity is to find an appropriate level of application of formalised managerial practices and tools that have succeeded in enforcing a wide range of applicability and have been very successful and in larger companies. Practically, by applying these tools, we strive to standardise and optimise processes, organisational practices and structures to achieve a global economic process that is as efficient and effective as possible across the enterprise. It is important to emphasise that it is not possible to apply these instruments according to the same standards as in large industrial enterprises because it may lead to the destruction of the uniqueness that originally determined the source of success for all small businesses.

It is known that an enterprise is seen as a set of human, material and immaterial resources, organised in a way to achieve the objectives set for its existence and proper functioning. If we analyse the resources of an enterprise, they can be classified and organised in different ways, when using complementary or alternative methods that take into account different resource characteristics (considered as priority or discriminatives), depending on the objectives of their use, or the way they are used. Choosing one method over another depends on a number of factors, including organisational culture, willingness to change, general vision of the company management and the process of creating internal value, socioeconomic context in which the enterprise competes.

Among the various theories, there are two which continue to relate to an adequate examination of the relating issues, namely: functional, which is a historical view resulting from the research of the specialisation developed by Smith, and the one covering more recent processes, which has expanded a lot over the last decades. T. H. Davenport and J. Short (1990) analyse the changes in the production and commercial scenario that led to the application of the Taylor model in search of an alternative model that can respond effectively to the relevant changes.

The authors argue that the purpose of Taylor's revolution at the beginning of the century was to increase the productivity of the organisation by applying the same engineering principles that have so far demonstrated the reliability of solving purely technical problems, to human work.

What Taylor created is called industrial engineering. However, in the early 1990s, two information age tools began to transform enterprises to the same levels as Taylor applied industrial engineering principles. In the work by T. H. Davenport and J. Short (1990), these two tools are information technology (the possibilities offered by computers, software applications and telecommunication services) and business process redesign (the analysis and redesign of work resource flows and processes within an organisation).

«The ideas and possibilities offered by these two instruments simultaneously have the potential to create a new type of industrial engineering, changing the way they are practiced and the capacity to be practiced» (Davenport and Short, 1990). In addition to the traditional vision of enterprise functions, it was discovered that an organisation attaches to the processes of achieving the goals of enterprise efficiency and effectiveness, both in terms of customer satisfaction and cost reduction. [...] A client-driven process management, capitalising on the human resources present in the enterprise, and continuous attention to innovation are key issues for the enterprise to be competitive (Davoli, 2003).

D. Pierantozzi (1998) believes that the enterprise that knows how to successfully change critical processes becomes more efficient, cheaper, faster and, consequently, increases customer satisfaction and loyalty.

However, it should be remembered that «process management not only means selecting a supplier and buying software, but above all, adopting a series of methods, a way of thinking and organizing work and acquiring skills, issues that are often underestimated [...]. Process analysis means practically focusing on objectives, manufactured products or services provided, and aggregating their activities around them, then assigning responsibility for the end-to-end process, and not on the function that at this moment becomes just an accessory» (Sinibaldi, 2009). A process is a set of structured and measured activities designed to produce a certain output for a particular market or customer (Davenport, 1995). In fact, all processes convert inputs into outputs by executing specific, resource-specific activities, respecting obligations and standards, to meet customer needs. The activities forming a process are «interdependent and aim at achieving a common goal such as identifying for each process the part of value creation for the output recipient, but which, for the process network that makes up the organization, coincides in the end with its values and its objectives The enterprise receives a certain input (of material nature, instructions and requirements of the client) to which it adds value-adding transformations using the organization's own resources, ie human resources, means of production and structures, transfers to the external environment the required output, product / service information» (De Risi et al., 1999).

The process network that is part of the enterprise's economic context is therefore a practical implementation of the company's strategies with regard to the final outcome and the way in which the available internal resources are exploited. Each process has a global, unique, complete and relevant input; all the activities that make up this process have a common goal, namely to achieve output. The same output cannot come from different processes, otherwise it would be impossible to identify the origin of this output (Ostinelli, 1995).

Regarding the applied methods and the purpose of our work, we will focus only on the analysis of the Six Sigma method, a quality management methodology based on statistical techniques. The

term *sigma*, in fact, is a standard deviation of the normal probability distribution, also known as the Gaussian distribution, which governs many physical phenomena. Six Sigma represents a variation from the average production of a process equal to 3.4 defects per million; it is therefore a synonym for the ability to reduce anomalies to a considerable level that cannot be neglected. In the manufacturing or manufacturing sphere it translates to the goal of producing everything in accordance with certain specific requirements, accepting a very small percentage of error. If a single-output standard process is envisaged, we can say that we follow this reasoning when the process itself is able to always produce identical outputs, according to established requirements, starting from the same inputs. The possibility of obtaining nonconformity must be connected to the phases necessary to obtain the desired input. The more activities are required to obtain the inputs in question, the greater is the likelihood that the deviations from the desired output value will be. In fact, any activity may be the source of a total or partial nonconformity, which may then lead to a nonconformity in the end result. Reducing the possibility of error at all stages of execution means reducing the possibilities to identify errors and nonconformities in the final product.

Six Sigma offers a quantitative approach to the issue of continuous improvement and cost reduction by reducing the variation in output of a process to the level most appropriate for a particular organization. The acceptable range depends on the product and is specified by two lower values, the Lower Specification Limit (LSL) and the Upper Specification Limit (USL). These two values will identify a service level that the enterprise intends to provide to its customers, which corresponds to a probability of effective compliance of outputs with the required specifications. Defining these levels will allow for the definition, for each output of the process, of an average, a standard deviation and, therefore, the form of effective data distribution (Sinibaldi, 2009).

Implementing a Six Sigma approach at the level of small firms can lead to reengineering of the company's management. The reengineering of the economic process is about fundamental reconsideration and radical redesigning in order to achieve profound and long-term changes in quality, cost, service, leadership, flexibility and innovation. In this respect, an economic process has to undergo significant changes in order to optimise productivity and quality, and radical changes, contrary to gradual changes, are made precisely to achieve these profound improvements at each stage of the production process (Ciappi et al., 2006).

Quality has always been an important objective for the enterprise pursuing environmental, economic and affiliation conditions. From a historical perspective, businesses have always resorted to quality control methods, especially post-production, using more or less statistical tools (the famous control sheets). Until the second half of the 1950s, concern over the quality of products or services did not take up much time and space. Only since the 1970s the quality concept has been amplified, being interpreted as a response to the requirements a product (Crosby) had to meet in the manufacturing process.

For example, Fitzgerold proposes a system of indicators for service enterprises, based on empirical research, suggesting a comparison of the company's performance with traditional management control. The model is based on measuring the final outcome (financial and competitive) and defining the determinants performance in achieving quality, flexibility, resources and innovation. While the former are largely common to non-service enterprises, the determinant values are specified depending on the type of offered services (professional, end-user or engross). The objective is to establish a balance between different categories of indicators in order to avoid excessive attention focused on short-term outcomes, which can compromise the entire gear or chain of values on which they rely in the medium term. The values examined by the model are the competitive outcome, the financial result, the quality of the services, the flexibility, the resource use and the innovation.

Basically, the main points considered are:

- *for competitiveness*: the market share on the following position, the sales growth rate and customer indicators;
- *for economic and financial results*: the revenues, the liquidity level, the capital structure and the financial market indicators;
- *for quality of service*: credibility (fidelity), the ability to respond, aesthetics / image, cleanliness / order, comfort, cordiality, communication, courtesy, skills, accessibility, availability and safety;
- *for flexibility*: the volume flexibility, the flexibility in distribution speed and the flexibility in specific achievements;
- *for the use of resources*: productivity and efficiency;
- *for innovation*: the results pursued in the innovation of the exploitation process.

### 3. Managerial accounting solutions

The activity of an economic entity involves the use of costs. These can be generating added value (e.g. direct production processes, welds, painting, etc.) or may not generate value (e.g. handling times, large stocks of raw materials, finished materials and products, inefficient processes, inefficient employees, etc.).

To be more explicit, referring to costs that do not add value, we can say that these can be generated by (Liker, 2004):

- *Overproduction*. It is one of the most important sources of loss. It can generate stocks, surplus staff and occupied spaces.
- *Stocks*. Large volumes of stocks of raw materials, materials, or finished products are blocking values that can be used for high-value purposes.
- *Waiting times*. The time when machines or staff are on hold can very easily turn into costs due to lack of productivity.
- *Unnecessary goods movements*. Transfers of various types of goods (raw materials, materials, semi-finished products, finished products) through various compartments and storage spaces can generate additional costs.
- *Incorrect processing or overprocessing*. Unnecessary operations included in the working processes or the design errors.
- *Unnecessary labour movements*.
- *Defects*. Poor processing can generate products that are not in compliance with the required standards.
- *Lack of using the creativity of employees*.

Lean Six Sigma is a philosophy or attitude that promotes ongoing efforts to ideally reduce and eliminate losses in the organisation. At the same time, Lean's main focus is on customer requirements, and the relations with them is viewed through value or non-value added internal processes. The value added tasks are the only operations the client is willing to pay for.

The Six Sigma methodology was developed by Bill Smith at Motorola in the late 1980s to provide a consistent data-driven approach to solving difficult business problems (Sharma, 2003). He used statistical data in manufacturing processes to determine the root causes of arised problems, develop and implement solutions, and monitor implementation of solutions to prevent occurrence of problems.

The idea of creating a flow in Lean production is to offer products and services only at the right time, in the right quantities and at the required quality levels.

Lean Six Sigma tools are the most commonly used for removing errors, waste, making value flows, etc (Cudney, Furterer & Dietrich, 2013) (see Figure 1).

This method or philosophy uses 5 steps (D - Define, M - Measure, A - Analyze, I - Improve, C - Control), each with a precise purpose (Brassard & Ritter, 2001).

The Defining Phase is the one in which the scaled project is defined. The goal of the Measurement Phase is to understand and measure the current processes. In the Analysis phase, we analyse the data collected in the measurement phase to identify the underlying causes of identified problems. In the Improvement phase, mechanisms and solutions for efficiency are developed and implemented. The purpose of the Control phase is to ensure that the improvements have had a positive impact and that they will be sustained and controlled.

For the system to be successfully deployed, it is required that it is supported by the decision-makers in viewv of the entity's precise objectives and involved teams if the project area is not too wide(Antony, Kumar & Labib, 2008).

The most commonly used tools in each phase are presented in the table below (Cudney, Furterer & Dietrich, 2013):

#### 3.1. Defining the problem

Six Sigma specialists begin by defining the problem. They identify the problems that are cause the operation to fall short of customer expectations try to fix them and with various tools (Pojasek, 2003).

The woodworking industry, and in particular the goods manufacturing branch has many advantages:

- the many active production processes within the entities allow a thorough study and the possibility of improving them;
- waste and scrap are tricky problems that can find solutions in Lean Six Sigma;

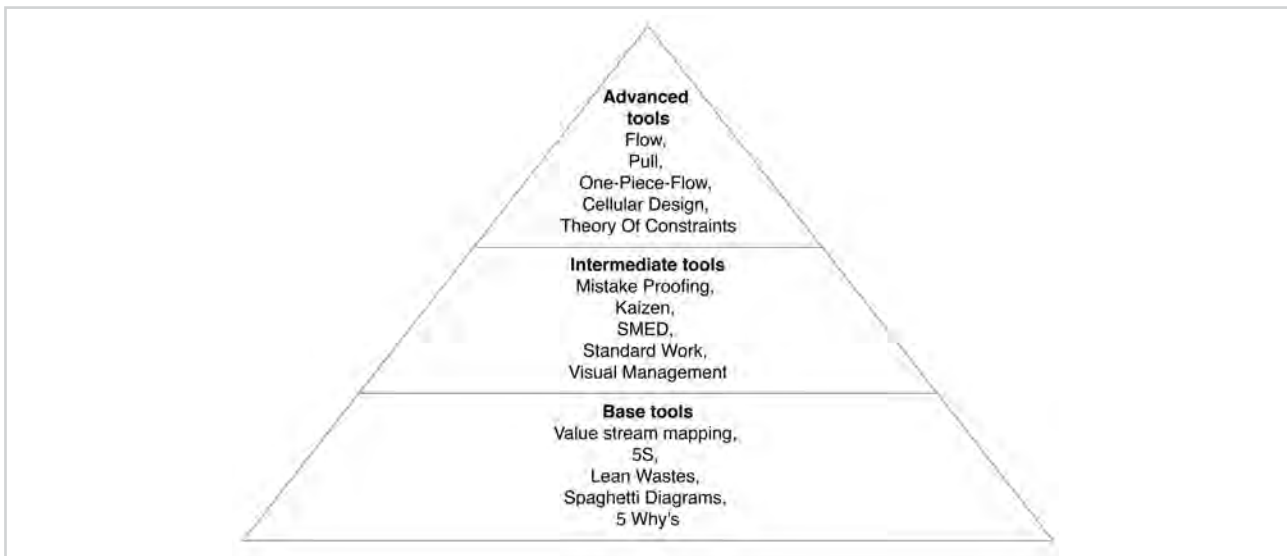


Figure 1:  
**Lean Pyramid**

Source: Cudney, Furterer & Dietrich, 2013

Table 1:  
**DMAIC tools**

Define	Measure	Analyse	Improve	Control
<ul style="list-style-type: none"> <li>• Definition of project</li> <li>• Shareholders analysis</li> <li>• SIPOC diagrams</li> <li>• Responsibility matrix</li> </ul>	<ul style="list-style-type: none"> <li>• Process map</li> <li>• Data collection</li> <li>• Value stream Mapping</li> <li>• Spaghetti diagrams</li> <li>• Pareto charts</li> <li>• COPQ</li> </ul>	<ul style="list-style-type: none"> <li>• 5 Why diagrams</li> <li>• Base statistics</li> <li>• Processes analysis</li> <li>• 5S</li> <li>• Kaizen</li> </ul>	<ul style="list-style-type: none"> <li>• PDCA</li> <li>• Cost / Profit analysis</li> <li>• One-piece Flow</li> <li>• Cellular design SMED</li> <li>• Kanban</li> <li>• Procedures</li> </ul>	<ul style="list-style-type: none"> <li>• Error checking</li> <li>• normalization</li> <li>• Visual management</li> <li>• Hypotheses testing</li> </ul>

Source: Compiled by the authors after Cudney, Furterer & Dietrich, 2014

- reduced production costs and maximized profits;
- improved product quality and increased customer satisfaction;
- an increased degree of involvement of human capital.

The objectives are multiple:

- to analyse production flows and find solutions to improve them by using Lean Six Sigma tools;
- to analyse the variability of inventories of finished products, raw materials and materials (where applicable);
- to determine true costing of finished products by using Lean Six Sigma tools (Value Stream Mapping, etc.);
- to use of specific tools in order to deal with problems, waste and other inefficiencies caused by inefficient processes.

The studied company (Flaro International SRL Botosani) was established in 1994 and the object of activity is the production of wooden toys. The company's turnover was in 2017 approximately EUR 850,000 and in 2018 approximately EUR 920,000.

The company is working on a niche market (the production of wooden toys). According to our science, the number of companies in Romania producing wooden toys is under 10.95% of the production is exported. The main beneficiaries are clients from Japan, France, Italy, Belgium and England.

In order to be able to draw a correct picture of the processes taking place within the company, it is necessary to study them through direct observation. In in such a way, they can create a true image of materials, persons, and information flows that form the entire production process.

Direct observation has some notable advantages:

- it can graphically present production flows;
- you can set time can be set separately for each subprocess and solutions can be offered for processes with large variation ranges;
- inter-process intermediate stocks can be calculated;
- Value Stream Mapping graph tool can be used as management support in later optimizations.

### 3.2. Measuring

The goal of the measuring is to quantify the problem by gathering information about the current situation. The key outputs of the measure phase include (Antony, Vinodh, Gijo, 2016): collecting data on the problem discovered in the process, how effective is the process.

Measurement of the various parameters in production processes is used to document the current state of the processes to be improved by collecting the necessary information. The activities carried out and the tools applied during the measurement phase may be: maps of processes, Values Stream Mapping, Spaghetti diagrams, Pareto charts, Cost Of Poor Quality (Figure 2).

Measuring of the various parameters relating to the processes is done by identifying their levels and determining important activities and their degree of complexity.

The constructed map tends to document a more detailed level of process. Thus, it may be useful to understand material flows or flow of information at a higher level.

Another tool used to measure the various parameters is the Value Stream Mapping.

It aims to provide useful information in the cost system, process efficiency, optimal inventory value, delays and waste control.

Below is a map of the value flow for the section of manufactured products (Figure 3).

The presented processes are of two kinds: those that bring value (green) and those that produce losses (red) (Figure 4).

As a result of studying the processes, work procedures have changed that led to a 80% reduction in scrap and waiting times.

Pareto diagrams present another mechanism that helps identify the critical areas that cause most problems. Also, it provides a summary of some vital issues.

The Pareto principle states that 80% of the problems are created by 20% of the causes, so that these profound causes can be investigated in the Analysis Phase.

Diagrams help us to position issues in order of importance and focus on eliminating issues with the highest frequency of occurrence (Atmaca & Girenes, 2013).

Thus, to generate charts, it is necessary to categorise defects and types of problems and determine their importance in current processes (Table 2, Figure 5 and Figure 6).

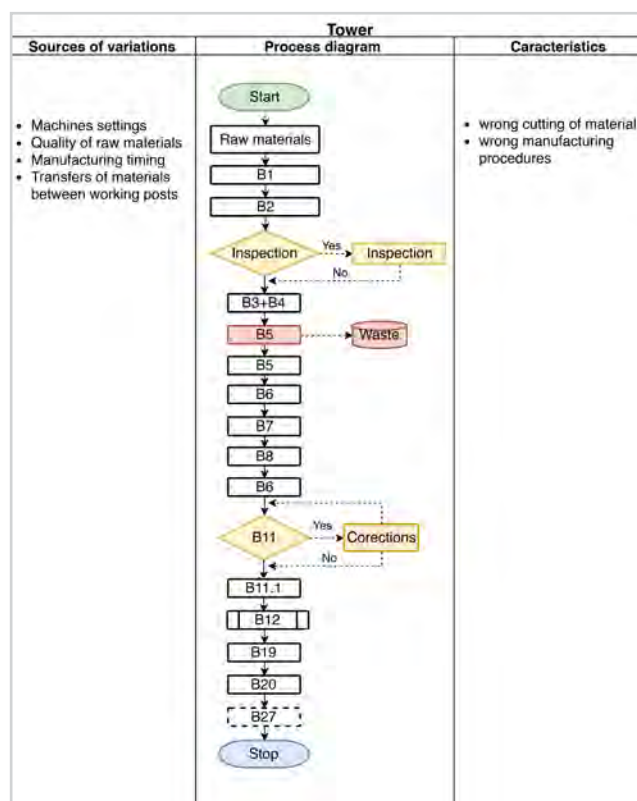


Figure 2:  
Values fluxes

Source: Compiled by the authors

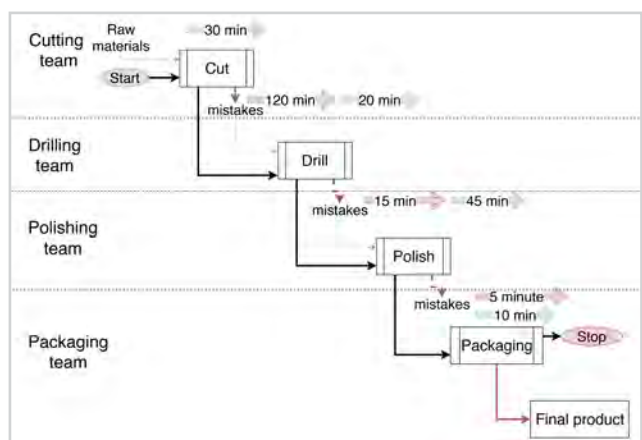


Figure 3:

### Value Stream Mapping

Source: Compiled by the authors

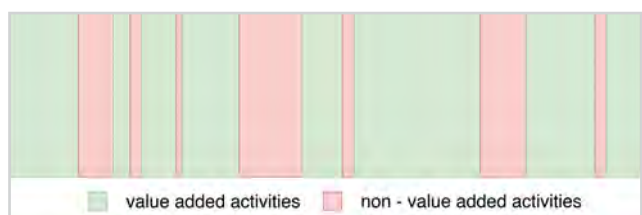


Figure 4:

### Operational Flux

Source: Compiled by the authors based on Rother & Shook (2003)



### 3.3. Analysing

On the analysis side, fishbone charts (cause-effect, Ishikawa diagram) have a major impact in determining the problems and their effects on processes.

The key questions that are answered in the analysis phase are as follows (Franchetti, 2015):

1. What is the current cycle time for the product or process?
2. What percentage of activities are value-added?
3. What are the non-value added activities?
4. What is the cost and profit to produce one unit?
5. What is the capacity of the process?

Thus, the problems are sorted, the causes are determined and their impact on the final product is calculated (Figure 7).

Another useful tool in causality analysis is the 5 Why diagram (Cudney, Furterer & Dietrich, 2013). The purpose of this tool is to generate the underlying causes of problems. The mechanism uses an incremental set of questions to determine the root causes of the problems (Figure 8).

As a result of the analysis of the causes, further action steps are being established to solve the problems that have arisen. On the improvement side, various tools can be used to illustrate the conclusions drawn from the analysis.

In the studied entity working in the woodworking industry, based on the carried out analyses, several directions of action have been determined which aim to improve the activity, increase the customer satisfaction and, implicitly, enhance the profitability by:

- improving the various parts of processes based on value flow maps: this has greatly accelerated processes by removing some redundant parts from them;
- reducing waste and scrap: the 5Why, the VSM, and the Pareto graphs have revealed the parts of the activity that generate the most problems; with these tools, action plans have been created that aim to minimise losses;
- a portion of the existing sub-processes have been optimised, modifying material flows from Push (pushing the materials from the bottom to the top) to Pull (dragging the materials to the top from the bottom). As a result of these changes, half-finished stocks were halved. At the same time, the workforce involved was redistributed for more efficient employment and streamlining of material and value flows.

Table 2:  
**Defect type/Occurrence**

Defect Types/ Event Occurrence	Data							Total
	day1	day2	day3	day4	day5	day6	day7	
def1 (incorrect cutting)	5	4	7	5	6	0		27
def2 (incorrect coating)	10	9	17	5	4	12		57
def3 (incorrect drilling)	4	2	0	2	1	0		9
<b>Total</b>	<b>19</b>	<b>15</b>	<b>24</b>	<b>12</b>	<b>11</b>	<b>12</b>		<b>93</b>

Notes: Project name: Tower. Period: 11.12.2017 - 18.12.2017

Source: Own processing based on examples of <https://asq.org/quality-resources/pareto>

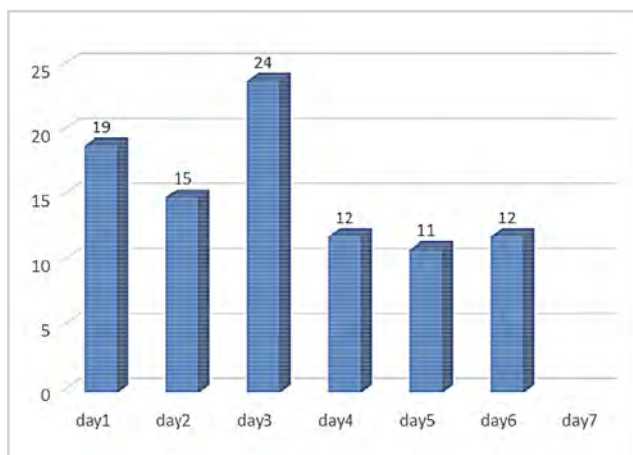


Figure 5:

**Pareto chart - Defect type / Event Occurrence**

Source: Own processing

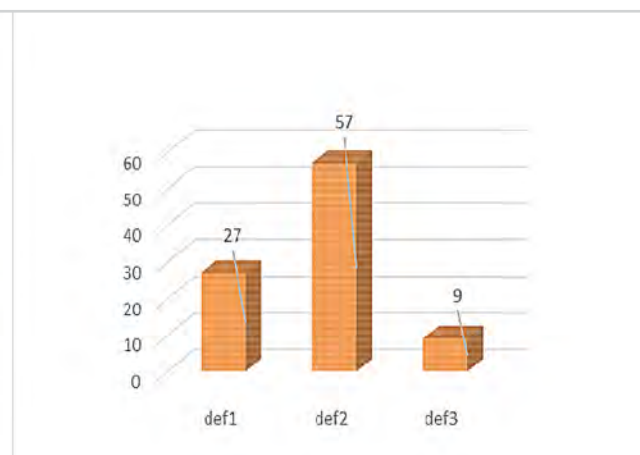


Figure 6:

**Pareto chart - Defects by type of operation**

Source: Own processing

A particular attention was paid to how to reconfigure the machines between the processing processes. Thus, the Single Minute Exchange of Dies (SMED) analysis determines the time of machine reconfiguration and testing in a particular process and inter-processes.

As a result of the analysis, a considerable reduction in machine reconfiguration and testing time has been achieved. At the same time, a greater involvement of the human factor directly responsible for this process has been achieved.

In the last phase of the efficiency plans, there is also a tool called PDCA.

### 3.4. Improve and Control

Kaizen as Lean's core is a milestone in several management approaches, such as Lean Production, Total Quality Management and Six Sigma. These have proved effective over time to resolve various business issues (Bhuiyan & Baghel, 2010).

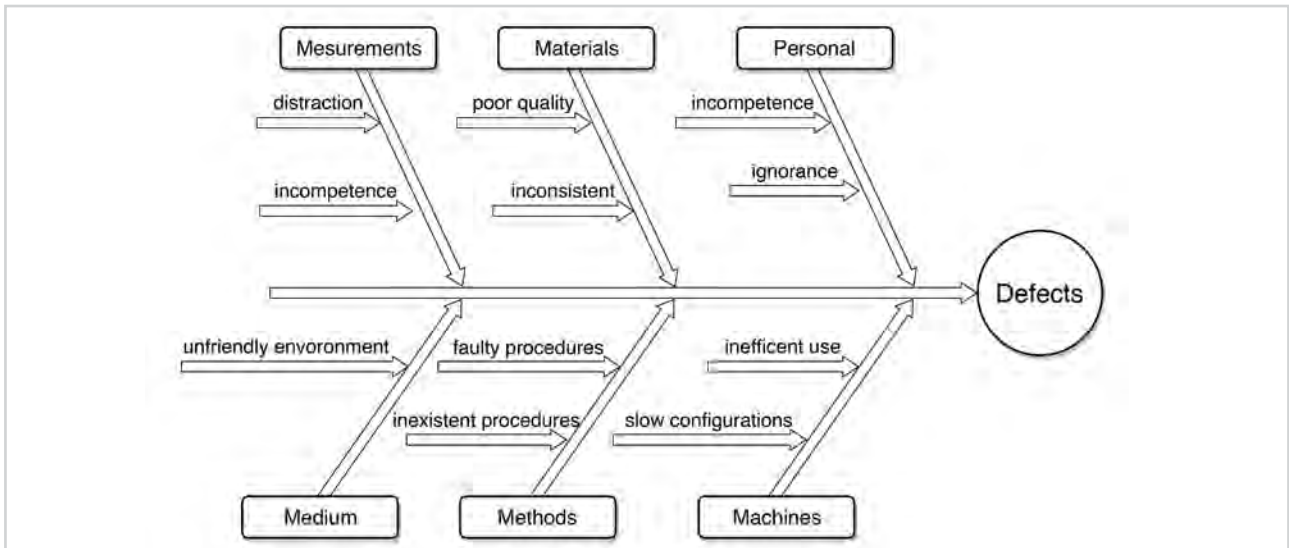


Figure 7:

#### Ishikawa diagram

Source: Own processing based on examples on <https://asq.org/quality-resources/fishbone>

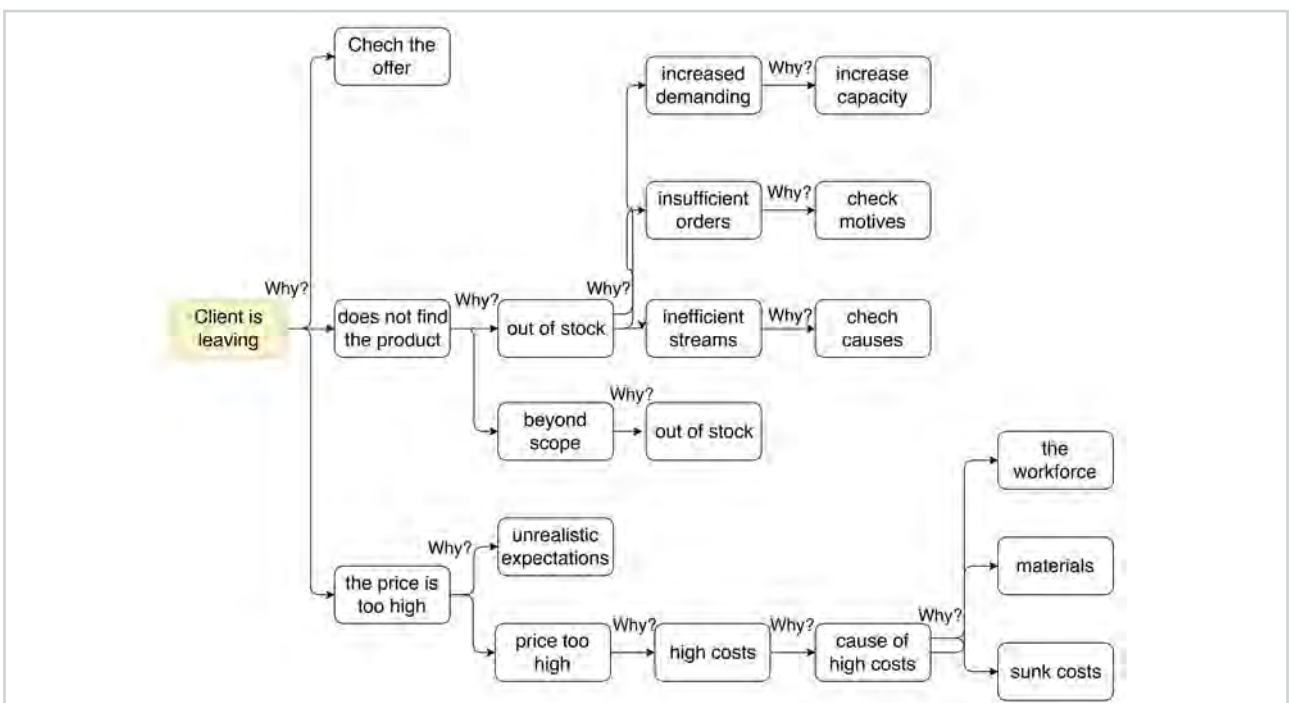


Figure 8:

#### 5Why's diagram

Source: Compiled by the authors

A well-known method that implements continuous improvement is the PDCA cycle.

The PDCA cycle has its roots in quality management and was perfected by Walter Shewhart in the 1930s as the Plan-Do-Study-Act (PDSA) (Schmidt et al., 2014).

An important feature of the PDCA is the emphasis on the planning stage. For this, several tools have been developed to simplify the process (Ishikawa Diagram, Pareto diagram and scatter diagram) (Bergman & Klefsjo, 2010).

Plan - Do - Check - Act (Plan-Do-Check-Act, 2018) is a four-step model that shows how changes will be made. The circle is closed because the cycle never ceases (Figure 9).

Thus, the loop itself presents the Lean philosophy (minor and continuous improvements).

#### 4. Research methodology

Consistent with the proposed purpose, this work is based on a holistic approach in that all stages of a production process are considered and analysed so that it can finally recommend measures to reorganise activity and responsibility within a production enterprises which are currently operating and are competing in the furniture production market.

As far as research strategy is concerned, it can be summed up to the following phases:

- collecting and analysing data to build the production process mechanism as it stands;
- designing an internal control system and analysing the possibility of redesigning internal processes;
- proposing an organisational structure compatible with internal processes;
- implementing corrective measures to stabilise the current situation.

Each of the phases listed above required the use of the techniques presented in the first part of the paper. The objective of our analysis was not focused on deepening the individual phases that make up the production process, but with their detailed mapping, we focused specifically on defining the connections between the different phases, identifying the information provided, the timing and methods to be followed to recreate a fluid flow within a well-defined process and to limit unforeseen problems and events.

#### 5. Results and Discussions

The cost of obtaining a quality level corresponding to the Six Sigma specifications will be even greater as far as the standard deviation of the distribution is higher, and therefore the distribution itself is more dispersed. Once critical aspects of the quality of the final product are determined, based on which the trend will be checked over time, this type of approach divides them into:

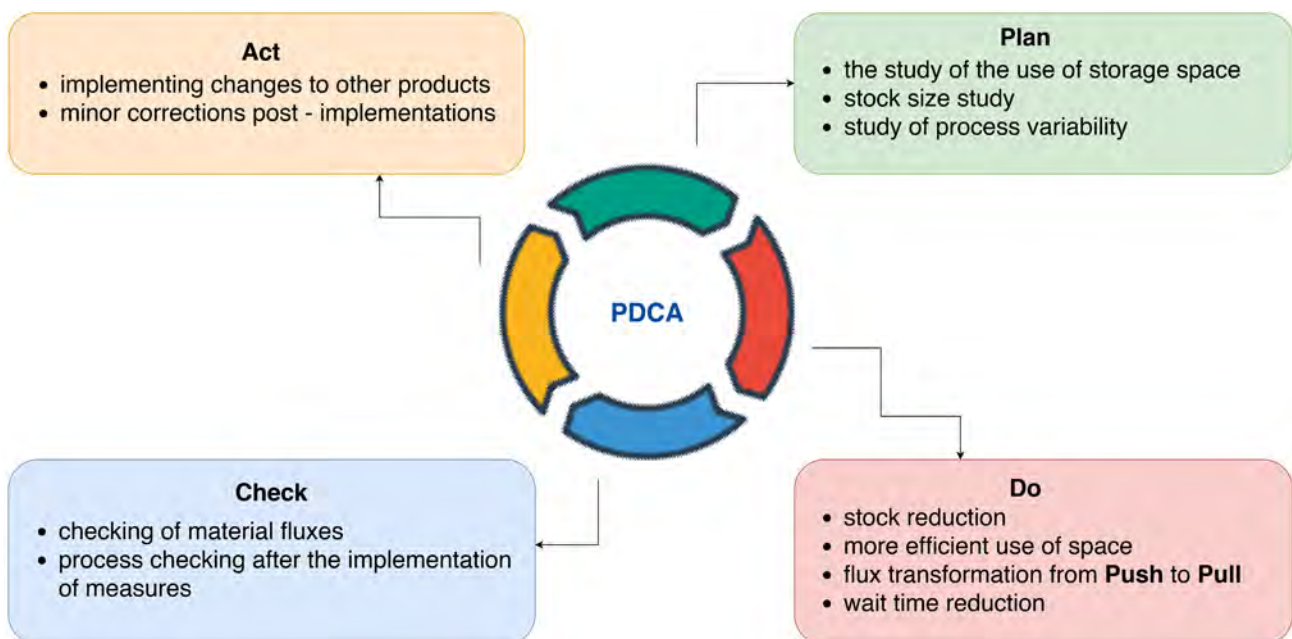


Figure 9:  
PDCA cycle

Source: Compiled by the authors

- External Critical to Quality: quality objectives expressed by the customer, therefore not expressed in terms usable for measurements and controls;
- Internal Critical to Quality: describes in measurable terms the client's quality objectives.

After defining the above aspects, it is necessary to identify the parameters of the production process that influence these qualitative measures and, of course, to analyse how the variations of these parameters influence the final quality of the production.

The application of the method is based on a cycle, called DMAIC, presented by Sinibaldi (2009), composed of:

- *Define*: the phase of defining project objectives, to be expressed by the translation of External CTO in Internal CTO;
- *Measure*: start measurements and collect data. This will allow for values for distribution, average and standard variation;
- *Analyse*: the phase that provides for the analysis of the data collected in the previous point, recognising which ones and how they can relate to the qualitative performance of outputs. In this phase, it may be useful to use charts such as Ishikawa, known as the fishbone diagram, which identifies the cause-effect relationship between process parameters and final outputs;
- *Improve*: after analysing the causes, it will be possible to apply the corrections, i.e. to design and implement those corrective actions to bring the outputs of the process into the previously defined acceptance intervals;
- *Control*: the created situation must be monitored to see if the changes made have actually produced the desired and planned goods.

In our case, the objective has been identified with the definition of the connections, roles and functions of a production structure that has expanded over time according to the operational needs of the enterprise. The flow of information in the production process and between it and the other economic or business processes has presented many gaps and inconsistencies. Creating tools dedicated to the distribution and collection of data and information in this process, as a result of defining the macro phases that make up it, aims at linking the different phases of the process, thus enabling it to provide information even in the external environment. Processes that make up an economic context must be able to communicate with each other in order to achieve the ultimate goal of the business.

The configuration and complexity of the functional and technical-organisational structure of economic entities, the variety of activities carried out and the continuous introduction of advanced technologies are factors that assert managerial accounting as an essential component of the accounting system. In this context, entities are constrained to a rational use of the factors of production in which the consumed resources are minimised and the benefits are maximised.

Moreover, it is necessary to look at the economic activities in terms of their valorisation by the clients. Starting from this premise, economic entities need to design management models that provide cost-effective design and follow-up solutions, analyse economic processes and optimise them both in terms of time horizons and value-added flows.

Thus, the use of Lean Six Sigma accelerates problem solving time, aims at reducing costs and losses, and increasing customer satisfaction.

## 6. Conclusion

Improvement approaches come and go, but improving the bottom line never goes out of style. The financial crisis is encouraging leaders and organizations to view Lean Six Sigma as an approach to reduce costs and keep the cash flowing (Snee, 2010).

As can be seen from the detailed analysis and the results obtained, the mapping of production processes proved to be more complicated than we expected, while practical interventions that could lead to tangible improvement and better results and much faster were met with much availability and management support.

This is probably also due to the fact that domestic management has reached such a high level of criticism that immediate action has been needed to ensure a return to optimum operating conditions. We believe that the economic reality within the enterprise, its size, staff training and operational habits lead to underestimation of strategic issues and actions, with medium to long-term results compared to practical, operational and short-term interventions.

In order to cope with a process of restructuring a consolidated economic reality, it is necessary to start with the awareness that we need to structure a gradual process, consisting of several micro-interventions related to a global strategy but with practical feedback, capable of involving those

who operate in production and analysis and motivate their participation by introducing a number of small improvements.

The risk associated with this type of activity is that micro-interventions are disconnected from each other and do not target a single final strategic goal.

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