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Școala Doctorală de Inginerie Industrială și Robotică

SUMMARY OF THE DOCTORAL THESIS

Contribuții privind optimizarea proceselor în tranziția
către o organizație SMART

Contributions on processes improvement towards
a SMART organization

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Introduction

In a scenario in constant transformation exerted by market pressure on one hand and the inflow of technology on the other, organizations must be responsive, evolve quickly and adapt to the required context, otherwise they would risk interrupting their activity.

The situation described above can be avoided if organizations rethink the way they carry out their activities by integrating, in addition to classic quality tools for measuring customer satisfaction and processes, digital technologies. The doctoral thesis contributes to the optimization of organizational processes by proposing a transition method to the Smart organization as well as by developing an application to monitor its evolution in relation to the proposed objectives.

The thesis is structured in two parts: first part consisting of chapters 1, 2 and 3 followed by second part chapters 4, 5, 6, 7 and 8. The first part of the paper represents the research in the field regarding the processes of an organization. The classical methods are presented for the purpose of improving the quality in organizations as well as suitable implementation frameworks. The digital tools and technologies are identified, as well as elements related to sustainability in accordance with the policies of the European Union. All these aspects will be used in the following chapters. The second part of the paper presents the objectives of the research, the research method used to identify the attributes and Smart criteria, the studies carried out towards achieving the objectives. Also within the framework of the studies, it is discussed to what extent traditional organizations that carry out their activities in the current general context, manage to identify opportunities for improvement, optimize and rethink their processes from the perspective of digital technologies in a sustainable framework so as to meet customer demands, as well as future research directions. The Quality 4.0 application is developed, the Tool for improving processes in organizations for monitoring the changes made in the organization.

Chapter 1. "The research context of the doctoral thesis" presents specific literature for the purpose of improving organizational processes, discusses the objectives and structure of the thesis.

Chapter 2. "Identification of classic quality improvement tools" presents classic quality improvement tools, models of excellence, and chooses the right implementation framework.

Chapter 3. "Identification of digital tools and technologies specific to Industry 4.0"

Current implementation methods and frameworks and the need to initiate change in organizations is presented. The importance of sustainability is highlighted by presenting the European framework containing regulations and policies in this regard. Conclusions are drawn.

Chapter 4. "Research method for highlighting the attributes that characterize Smart organizations "It contains a separate analysis of the terms referring to the Smart organization within the specialized literature to identify which were the terms that define a Smart organization. The terms obtained from the study encompass innovative concepts and technologies specific to Industry 4.0, which demonstrates the direct link between digital technologies and the concept of Smart organization.

Chapter 5. "Research and contributions for transforming the traditional organization into a Smart organization" In this chapter, a study was developed, a model for optimizing organizational processes starting from the processes in which the need for improvement was identified, considering their main objective of being competitive. A similar study was conducted in an electrical equipment organization. The results obtained were correlated with the specific elements of Industry 4.0. Subsequently, conclusions were stated.

Chapter 6. "The sustainable perspective of the Smart organization transformation method" Analysis performed within an electrical equipment organization to calculate the carbon footprint.

Chapter 7. " Development of the Quality 4.0 application" This chapter analyzes the sustainability perspective within an organization, an objective that must be aimed at by any organization aiming

to improve processes. It is based on the study carried out on the carbon footprint in of electrical equipment organization. The conclusions obtained constitute benchmarks for the development of the proposed model.
Chapter 8. "Thesis conclusions and contributions regarding process optimization from an Industry 4.0 perspective" By synthesizing what was obtained in the previous chapters and using the EFQM framework, the process improvement tool was obtained in the form of an application. The developed application helps to easily implement the obtained model. It indicates at any time, based on input data, to what extent the organization met its proposed objectives.

Chapter 1. The research context of the doctoral thesis

In the specialized literature, numerous authors have designed organizational management models that ensure the implementation of revolutionary concepts belonging to Industry 4.0, the barriers and factors that influence organizational progress have been studied, as well as the way in which traditional measurement and control tools used in the field of quality, manage or fail to demonstrate their effectiveness in the organizational framework, characterized by Industry 4.0.
The rapid flow of information, communication networks, the economic and cultural context, which are in continuous dynamics, are just a few factors that drive and shape customer behavior, their requirements becoming increasingly complex and demanding. At the same time, the international context is marked by a series of opportunities generated and driven by technological advancement. Therefore, the period after the digital revolution or the so-called Industry 5.0 constitutes a new challenge that reinvents the relationship between man and machine, redefining the skills of the modern worker, rethinking processes so that they provide products of the future, integrated into a circular and sustainable economy. With Industry 5.0, another characteristic becomes important, namely resilience, the ability of people to adapt, to face challenges, profound changes, to withstand the shocks generated by continuous evolution. Industry 5.0 was propelled by the SARS-CoV-2 epidemic. The need for socialization, boosted the widespread use of communication and connection services via the internet, transformed office work as we knew it, becoming global users of online platforms and remote work toolkits. Everything that had been applied up to that point in terms of performance and organizational culture as we knew them, was adapted to suit the transformations that had occurred. In conclusion, we can say that any technological revolution, regardless of how it began and how it manifested itself, has reconfigured not only the global economy but has led to the progress of humanity.
The doctoral thesis aims to optimize the business strategies of organizations, so that they can ensure economic growth based on innovation and at the same time carry out sustainable activities. *The main objective* of the doctoral thesis is the transition of a classic, standard organization to a Smart organization, which meets customer requirements and uses digital technologies from the Industry 4.0 sphere. This objective will be realized with the creation of a tool that can record, monitor, and report at any time the stage in which the organization is in terms of fulfilling the criteria for transforming into a Smart organization.

From here, the following secondary objectives emerge:

OS1: Identifying specialized literature for improving organizational processes;
- Identifying specialized literature and establishing thesis objectives
- Classic tools and models for quality improvement
- Choosing the right framework for implementation

OS2: Developing a method that can be used to transform a traditional organization into a Smart organization;

- Research method for identifying Smart attributes
- Research conducted
- Conclusions

OS3: Case study to identify current customer requirements and how they can be met;

- Case study to identify customer requirements
- Correlating results with Industry 4.0 specific tools
- Conclusions

OS4: Case study. Sustainability of the proposed model;

- Studying the framework and proposing the method for sustainability analysis
- Carrying out the sustainability study
- Conclusions

OS5: Defining the Tool for Improving Organizational Processes: Quality 4.0;

- Identifying the tool for improvement
- Process measurement
- Steps for the application development
- Initiating application development
- Conclusions

OS6: Conclusions, main contributions regarding process improvement from the perspective of Industry 4.0 and Quality 4.0

To achieve the proposed objectives, the following activities were carried out:

- Documentary research on the evolution of quality improvement tools
- Bibliographic research on the implementation framework of the quality improvement tool
- Documentary research on digital technologies
- Bibliographic research on sustainability
- Case study to identify Smart attributes
- Case study for process improvement in the field of stacking equipment and electrical equipment
- Case study for carrying out the GHG inventory and carbon footprint calculation
- Documentary research for the development of the Quality 4.0 application

The novelty of this thesis consists in proposing a method by which traditional organizations, after identifying processes that require improvement and implementing tools from the field of digital technologies can initiate the transition to a Smart, modern organization and monitor their progress with the help of the Quality 4.0 application.

Chapter 2. Identifying classic quality improvement tools in traditional organizations

To understand the direct link between the notion of quality and its evolution with the transformations generated by the industrial revolutions, it is necessary to study the specialized literature and the changes that have occurred at the level of organizations. Starting with the first reports on improving performance in organizations of Frederick Winslow Taylor's work "Principles of Scientific Management" [T01] and up to Deming known for his contributions to statistical process control and especially for the PDSA (Plan - Do - Study - Act) cycle which he called the „Shewhart cycle" applied to improvement, from which the PDCA (Plan - Do - Check - Act) cycle [M03] evolved, applied to the development of a new product and later modified by Ishikawa, continuing with Bill Smith, while working at Motorola in 1987, who introduced the Six Sigma concept to the industry [B02], these techniques revolutionized the industry and systematically improved the results of organizations. More than ever, with innovations in all fields of engineering, it is necessary to redefine and rethink the way we evaluate the quality of services and products, feeling the need for progress in this area. Below in Table 2.1, the classic techniques used for quality improvement are represented.

Table 2.1 Tools and methods for quality improvement

Method	Initiator	Features	Observations
PDCA Cycle (Plan-Do-Check-Act) PDSA Cycle (Plan-Do-Study-Act)	William Edwards Deming	P- plan, formulate the purpose D - do C - check A - act P- plan D - do S - analyze A - act	Model taken from Shewhart's cyclic concept in 3 steps: Specifications - Production-Inspection
Six Sigma (DPMO) Quality control technique	Bill Smith	- 3.4 defects in a million opportunities, a target of 99.99966% no defects; - describes the standard deviation from the mean	Used to describe the limits of design margin and the quality of the products obtained
5S Method	Toyota Production System	- Seiri/Sort (sort, remove useless things) - Seiton/Set in order (order) - Seiso/Shine (cleaning) - Seiketsu/Standardize (standardize the order) - Shitsuke/Sustain (maintain order and discipline)	A method used to improve quality that is complementary to the Kaizen principle
Metoda Taguchi	Genichi Taguchi	Introduces the Quality Loss Function (QLF); this is a mathematical representation between product quality and the financial loss associated with deviations from a target value.	Statistical method for improving the quality of products and manufacturing processes
Pareto Principle (method 20/80)	Joseph M. Juran	Graphical method based on the fact that 80% of defects occur due to 20% of causes.	It identifies factors, but does not provide clues to the source of

			failure causes, so it must be used in conjunction with a complementary method
Cause and Effect Diagram (Fishbone diagram)	Kaoru Ishikawa	Graphical method that helps identify the cause of a problem	Useful for identifying the root causes of a problem
Zero Quality Control	Shigeo Shingo	It is based on error prevention and correction; it uses sensors that detect the presence of defects, as well as other similar devices	Quality must be controlled at the source of the problem and not after it manifests itself; he disputes the use of statistical methods
Just in Time	Shigeo Shingo	A production strategy based on reducing inventories and associated costs	It is based on inventory reduction
Kanban	Taiichi Ohno	It is based on tasks that are in progress. Visualization of processes and production flow by using visual indicators	Helps improve production flow
Shainin	Dorian Shainin	Of all the causes that could cause variation in the system (process interruptions), one cause of the problems manifests itself more strongly than the others	Uses the Pareto principle

In order to identify business excellence models and implementation and evaluation frameworks suitable for the proposed objective, the excellence model EFQM emerged as the appropriate evaluation framework [H01] ***, on which we focused for the use of its criteria for evaluating the results obtained after implementing the proposed method for improving organizational processes. The evaluation of an organization according to the EFQM model is carried out according to three plans: Direction, Execution and Results and seven evaluation criteria as in Table 2.2.

Table 2.2 Evaluation criteria and sub-criteria according to the EFQM model

Evaluation plans	Criterion	Subcriteria
Direction	1. Purpose, vision, strategy 100p	1.1 defining the purpose and vision 20% 1.2 identifying and understanding stakeholders needs 20% 1.3 understanding the ecosystem, capabilities, and major challenges 20% 1.4 developing a strategy 20% 1.5 design and implementation of a performance management system 20%
	2. Organizational culture and leadership 100p	2.1 Encouraging organizational culture and values 25% 2.2 Creating the conditions for the change to occur 25% 2.3 Encouraging creativity and innovation 25% 2.4 Union and involvement in vision, purpose, and strategy 25%
Execution	3. Stakeholder engagement 100p	3.1 Customers: creating a lasting relationship 20% 3.2 Employees: attract, develop, involve, and retain 20% 3.3 Business stakeholders: support and provide security 20% 3.4 Organization: Contributes to development, well-being, and prosperity 20% 3.5 Partners and suppliers: build relationships and provide support with lasting value 20%
	4. Creating sustainable value 200p	4.1 Designing value and the way it is created 25% 4.2 Communicate and sell value 25% 4.3 Deliver value 25% 4.4 Define and implement the overall experience 25%
	5. Define and implement the overall experience 100p (20%)	5.1 Target performance and manage risk 20% 5.2 Transform your organization for the future 20% 5.3 Drive innovation and use technology 20% 5.4 Leverage information, data, and knowledge 20% 5.5 Manages assets and resources 20%
Result	6. Stakeholder perception 200p	6.1 Customer perception results 6.2 Results on people's perception 6.3 Results on the perception of business and government stakeholders 6.4 Results on society's perception 6.5 Results regarding the perception of partners and suppliers
	7. Operational and strategic performance 200p	7.1 Achievements in fulfilling its purpose and creating sustainable value 7.2 Financial performance 7.3 Meeting stakeholder expectations

		7.4 Achieving Strategic Objectives 7.5 Achievements in performance management 7.6 Achievements in driving transformation 7.7 Predictive measures for the future

Choosing the right framework for implementation was concluded to be the process map.
In conclusion, although traditional organizations use the established methods of continuous improvement and evaluation presented above, they face difficulties related to the increasingly diversified requirements of customers, the increasingly strong competitive environment, and technological developments, therefore they are forced to rethink their processes. To avoid difficulties such as those related to communication, organizational structure, data transfer, they must adapt to change, integrate the novelties brought by Industry 4.0, ensuring their transition to a Smart organization.

Chapter 3. Identification of digital tools and technologies specific to Industry 4.0

The development of a model for optimizing an organization's processes, addressed in the author's works [V03], [V04], considers the need for digitalization that follows the direction of the European Union. Traditional organizations must adapt their business strategies to cope with the competitive environment E. Siachou et al., 2020 [S04]. Another solution for implementing a cyber model, Zhang et al. [Z01] is proposed on three levels: the intelligent data collection system (cyber control system), the IoT-based monitoring system, and the physical system represented by instruments, people, etc. Nowadays when we refer to Industry 4.0 we must consider the following specific identifiers: Cloud Computing, Big Data, Additive Manufacturing (3D printing), Internet of Things (IOT), Cyber Physical Systems (CPS), Virtualization (Digital twin), Software Modeling and Simulation and the scope can be expanded. These, beyond the obvious role previously specified, sometimes represent more economic tools and solutions in terms of achieving the goals pursued by the enterprise and are therefore within their reach [M04]. Since there is not enough research and a well-defined implementation framework for applying the changes brought about by the rapid evolution of technology, this thesis aims to identify the means and framework through which a small and medium-sized enterprise can achieve process improvement and quality, in the context of Industry 4.0 and the transformation into a Smart organization. The Smart Ecosystem within an enterprise is generally built with the following tools: Cloud Computing defined by the ISO/IEC 17788:2014 standard [I04], Big Data according to the ISO/IEC 17788:2014 standard [I05], Additive Manufacturing [I06], Internet of Things (IoT) defined by ISO/IEC 20924:2024 [I07], Cyber Physical Systems, Virtualization (Digital twin). These are just a few tools that we need to consider and that are currently required to be used to keep up with major technological changes. Regarding current software methodologies for process improvement, we can say that they have a remarkable process improvement potential, however they become accessible only on the basis of training. In the field of quality, programs such as: TrackWise Digital, CAQ AG, Cority Quality Management Software or IdeaGen Quality Management are renowned. There are significant differences between organizations and to face competition, it is necessary for traditional ones to rethink and redefine their processes, along with the implementation of digital technologies. Currently, Industry 5.0 is being envisioned, the future from the perspective of the organization and the environment. Sustainability is part of a broad framework that proposes to organizations the implementation of the 17 SDGs (Sustainable Development Goals), a measure that provides confidence in the organization and its ability to act responsibly in its activity. (ISO 26000:2010 Social responsibility) [I08]. In this context, the EU's ambitious proposals related to the reduction of CO2 emissions to mitigate the devastating climate effects and also the author's study [V05] conducted for the design of a sustainable tool for improving the processes of a small and medium-sized organization in Romania, are included. Carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), fluorocarbons (F-gases) are the gases with the greatest impact on global warming. While developing their own products, the organizations analyzed are concerned about the impact of their activities on the environment and closely follow Directive 2003/87/EC [E01] and the implementation of Regulation 2066/2018 [E02]. The GHG Guidelines (GES) protocol belonging to WRI (World Resource Institute) and WBCSD (World Business Council for Sustainable Development) [G04] classifies emissions according to how they were generated, namely emissions belonging to Scope 1, 2 and 3 as in Fig. 3.5.

Scope 1 means everything owned by the organization that generates greenhouse gas emissions.

Scope 2 everything related to purchased electricity, what connects to electricity and generates indirect emissions.

Scope 3 means indirect emissions.

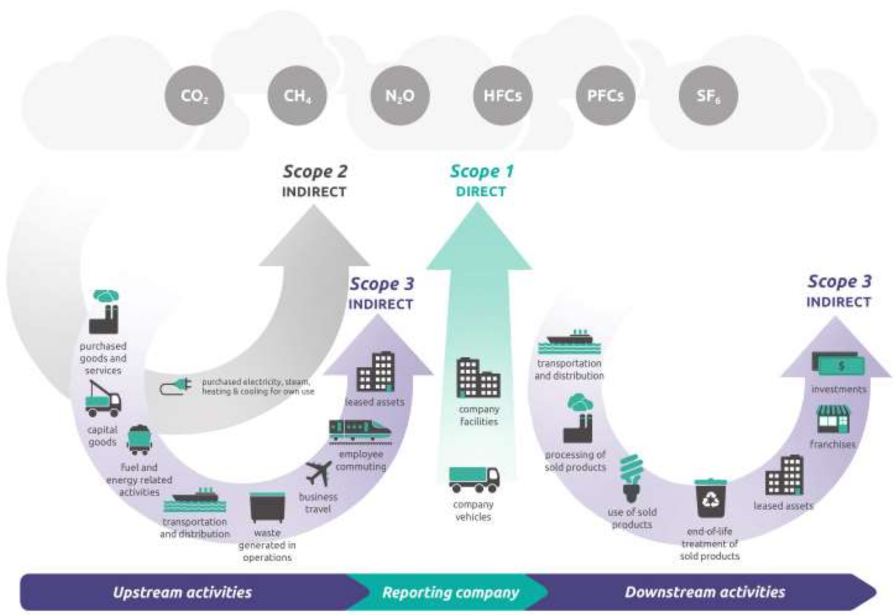


Fig. 3.5 Overview of areas and emissions along a value chain. (*Source: Greenhouse Gas Protocol GHG*)

GWP - Global warming potential measures how much infrared thermal radiation a greenhouse gas would absorb, after being emitted into the atmosphere, over a certain period of time.
Because CO_2 has a GWP warming potential 25 times lower than CH4, for example, but can remain in the atmosphere for 150 years (while other emissions remain in the atmosphere for only 10 years), we will only consider CO_2 emissions among all anthropogenic emissions. Another argument for which the calculations mainly reflect the presence of CO_2 emissions is the following: according to the EU report, in 2021 CO_2 emissions constituted 80% of total greenhouse gases in the atmosphere.

From this, conclusions emerge regarding the current state of research and development and the need to transform traditional organizations into Smart organizations as well as the concept of improving and transforming an organization from a standard organization into a Smart organization [Fig 3.6]
The result is that a standard organization that applies classic quality improvement methods, but accesses techniques specific to Industry 4.0 and pursues the development of activities following sustainability, will be able to measure its activity complying with the new standards in the field, and will be able to become an organization adapted to the new market requirements.

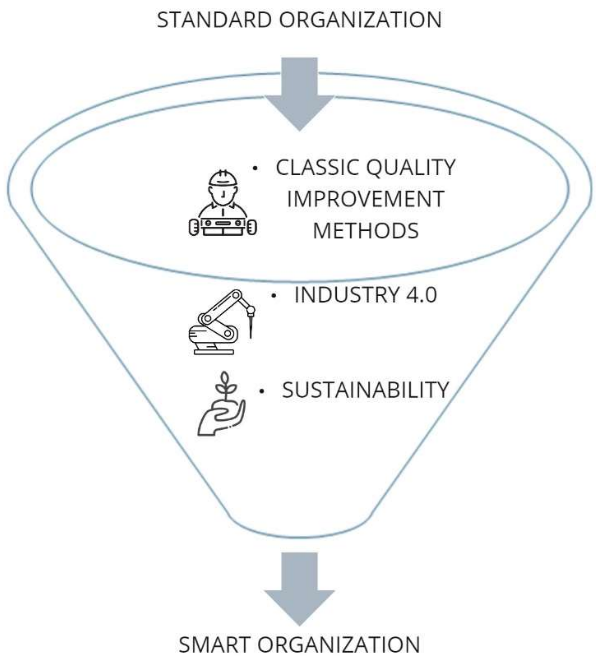


Fig. 3.6 The concept of improving an organization

Chapter 4. Research method for highlighting the attributes that characterize Smart organizations

Romanian organizations, in order to be competitive, must be flexible and adapt to new customer requirements in accordance with digital technologies, requirements that they can only meet by achieving Quality 4.0, derived from Industry 4.0. Similarly, achieving operational excellence is an essential criterion in achieving these goals and the operations they carry out must be under the sign of sustainability.
To achieve this objective, we identified the following questions:

- What are the attributes, keywords, that characterize a Smart organization
- What is the relationship between a Smart organization, profit and/or innovation
- What are the internal and external factors (Enablers) that help organizations become Smart and here we refer to processes, the digitalization of equipment, the transformation of organizational culture, as well as what influence of employees if they are digitally literate, how can this aspect become an advantage in its transformation

- How can be analyzed the level of digital transformation of an organization and/or the its state at a given time
- The impact of the organization's transformation on the environment. Sustainability data obtained

To answer the above questions, an analysis was conducted on three databases, covering a period of eight years, to highlight the attributes that characterize Smart organizations. When we think of a Smart organization, we assume that we have an entity that follows digital transformation, which has implemented modern techniques such as: IoT, BigData, Cloud Computing, ML, IoT, Additive Manufacturing, Digital Twin, Augmented Reality, Blockchain.
To demonstrate the above assumption, we conducted a literature review in 3 of the most comprehensive databases, namely: Springer (Germany), Taylor & Francis (United Kingdom), Elsevier (Netherlands). The search technique used the filters below.

1. Relevant period assessed 2016-2024;
2. The expression used: *Smart Organization*;
3. Using the site's filtering, only articles in English were searched, excluding conference abstracts, conferences, editorials and article reviews, books;
4. Sciences researched: Engineering, Business, Management and Accounting, Computer Science, Engineering, Economics and Finance, Environmental Sciences, Materials Science; Business Strategy and Environment;
5. The results obtained were selected in a table.

Keywords were extracted from the final articles obtained from each database, using a program in Python. [E06] Finally, it is observed that, centralized from the 3 databases, n=91 unique words remained. They were refined according to certain criteria and finally the resulting terms were grouped by categories of interest: Digital Transformation, Sustainability, Industry 4.0, Employees as in Table 4.2.4. Grouping by categories was also made considering the affinity towards the pre-established domains, as in Table 4.2.4

Table 4.2.4 Centralizer of key terms that define Smart organizations

Paper& DataB.	Category	Keyword	Absolute frequency
GTF13	Digital transformation	Emerging trends	2
GTF11	Digital transformation	Innovation and infrastructure	4
GTF10	Digital transformation	Responsible innovation	5
GTF13	Digital transformation	Data quality	2
GE4	Digital transformation	Data-driven	3
GTF12	Digital transformation	Big data analytics	3
GTF11	Digital transformation	Smart card data	4
GE5, GS9, GTF8	Digital transformation	Big data	14

GTF13	Digital transformation	Shared mobility	2
GTF13	Digital transformation	Design research	2
GTF13	Digital transformation	Autonomous shipping	2
GTF13	Digital transformation	Large scale urban sustainable development projects	2
GE4	Digital transformation	Smart design	3
GTF12	Digital transformation	Smart mobility	3
GTF12	Digital transformation	Smart home	3
GTF12	Digital transformation	Virtual reality	3
GTF12	Digital transformation	Urban planning	3
GTF12	Digital transformation	Space syntax	3
GTF11	Digital transformation	Built environment	4
GTF10	Digital transformation	Smart contract	5
GS14, GTF7	Digital transformation	Smart city	11
GS16, GTF4	Digital transformation	Smart manufacturing	13
GTF9, GS13	Digital transformation	Smart grid	11
GTF13	Digital transformation	Digitisation	2
GTF13	Digital transformation	Digital inequality	2
GTF13	Digital transformation	Digital society	2
GTF13	Digital transformation	Digital business ecosystem	2
GE4	Digital transformation	Digital resources	3
GE3, GTF12	Digital transformation	Digitalization	4
GTF10	Digital transformation	Digital divide	5
GTF9	Digital transformation	Augmented reality	6
GTF12	Digital transformation	User experience	3

GTF9	Digital transformation	Digital transformation	6
GTF8	Digital transformation	Supply chain management	8
GS17	Digital transformation	Global digitalization	10
GTF5, GS10	Digital transformation	Digital twin	14
GTF5, GS10	Digital transformation	Digital	28
GE4, GS4	Digital transformation	Cybersecurity	29
GS11	Digital transformation	Sensors	26
GTF13	Sustainability	Building performance	2
GTF13	Sustainability	Climate policy	2
GTF13	Sustainability	Renewable energy	2
GTF13	Sustainability	SDG 9: industry	2
GTF12	Sustainability	Sustainable mobility	3
GTF12	Sustainability	Climate-smart agriculture	3
GTF12	Sustainability	Carbon footprint	3
GTF12	Sustainability	Energy storage system	3
GE3	Sustainability	Sustainability	4
GTF10	Sustainability	Climate change	5
GTF6, GE4	Sustainability	Circular economy	8
GE5	Industry 4.0	Scaling process	2
GE5	Industry 4.0	Lean	2
GE5, GTF13	Industry 4.0	Maturity model	2
GTF13	Industry 4.0	Agility	2
GTF13	Industry 4.0	Production control	2
GTF13	Industry 4.0	Natural language processing	2
GTF13	Industry 4.0	Federated learning	2
GTF13	Industry 4.0	3D printing	2
GTF13	Industry 4.0	RFID	2
GTF12	Industry 4.0	Lean manufacturing	3
GTF12	Industry 4.0	Lean Six Sigma	3
GTF12	Industry 4.0	Building Information Modeling (BIM)	3
GTF12	Industry 4.0	Business model innovation	3
GTF12	Industry 4.0	Business model	4
GE3	Industry 4.0	Smart technologies	4
GE3	Industry 4.0	Smart data	4
GTF11	Industry 4.0	Smart factory	4
GE5	Industry 4.0	Self-assessment	8
GE2, GS7, GTF1	Industry 4.0	Industry 4.0	28
GTF13	Industry 4.0	Social Internet of Things	2

GTF13	Industry 4.0	Wireless network-on-chip	2
GTF12	Industry 4.0	Automated driving	3
GTF12	Industry 4.0	Remote sensing	3
GS15	Industry 4.0	Cloud Computing	11
GE5, GTF3, GS2	Industry 4.0	Blockchain	26
GE5, GS1, GTF2	Industry 4.0	Internet of things	32
GTF12	Industry 4.0	Convolutional neural network	3
GE4	Industry 4.0	Industrial Artificial Intelligence	3
GTF12	Industry 4.0	Decision making	3
GS12, GTF9	Industry 4.0	Deep learning	14
GS6, GTF5	Industry 4.0	Machine learning	32
GS3, GTF2	Industry 4.0	Artificial intelligence	40
GTF12	Industry 4.1	Predictive maintenance	3
GE5	Employees	Resilience	2
GTF13	Employees	Human-centered computing	2
GTF13	Employees	Capability development	2
GE4	Employees	Education	3
GTF13	Employees	structural health monitoring	2
GTF12	Employees	Food security	3
GTF9, GS5	Employees	Coronavirus	30
GS8	Employees	Healthcare	43

Next, we will analyze the variability of the data sets in order to observe the type of distribution of each set that describes a Smart organization and determine whether the distribution is uniform or not, and to observe the correlations/links between them and between the terms of the sets in order to achieve the proposed objective.
For each category we calculate:

- arithmetic means $\overline{x}$ with the formula (1) ;

$$\overline{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad (1)$$

- variance σ^2 (dispersion, the degree of dispersion of the data from the mean and represents the ratio between the sum of the squares of the deviations from the arithmetic mean $\overline{x}$ and the number of members) with the standard formula (2)

$$\sigma^2 = \frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n} \quad (2)$$

- Standard deviation σ obtained with the formula:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n}} \quad (3)$$

- The median of the data set is obtained with the formula:

$M_e = (n+1)/2$ odd data set *(4)*

M_e = [n/2 + (n+1)/2]/2 data set even *(5),*

where n is the n^{th} term, respective the n+1 term

- The mode is the value with the highest frequency
  We use the function MODE.MULT in Excel and we notice that the first 3 distributions are bimodal
- Asymmetry of a distribution (skewness) characterizes the degree of asymmetry of the distribution around its means. Pearson's coefficient of asymmetry can be used (6) [P02], or the formula (7) based on the third moment, more precisely, with the help of Data Analysis:

$$S=3[(\overline{x}-Me)]/\sigma \quad (6)$$

$$S = \frac{n}{(n-1)(n-2)} * \sum \frac{(x_i-\bar{x})^3}{\sigma^3} \quad (7)$$

- Skewness (8) we will calculate it as follows:

$$K = \frac{n(n+1)}{(n-1)(n-2)(n-3)} * \sum \frac{(x_i-\bar{x})^4}{\sigma\text{^}4} - 3\frac{(n-1)^2}{(n-2)(n-3)} \quad (8)$$

We will represent it as in Fig. 4.2.4 a, b, c, d

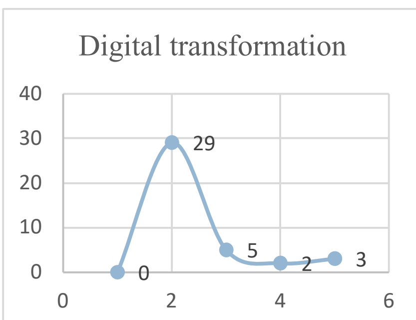


Fig 4.2.4 a) Distribution graph of Digital transformation

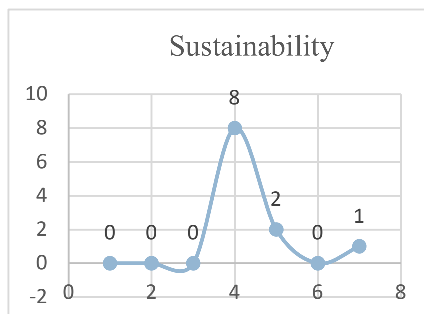


Fig 4.2.4 b) Graphic representation of distribution Sustainability

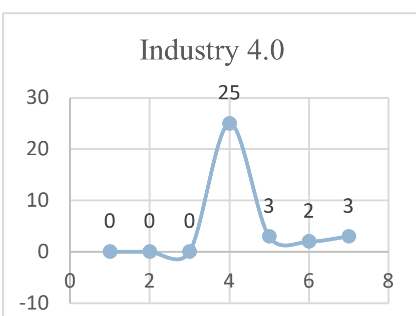


Fig 4.2.4 c) Graphical representation of Industry 4.0 distribution

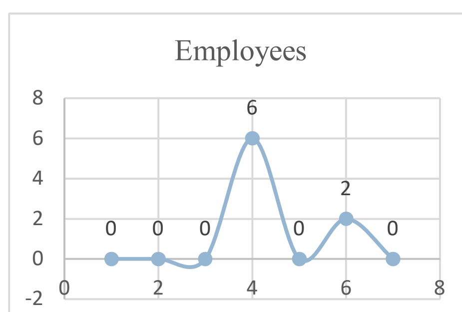


Fig 4.2.4 d) Graphical representation of Employees distribution

In conclusion, we obtained the following:
The words in Fig 4.2.4 a) Digital transformation, have the highest frequency on the interval (6.51, 20.24), respectively for this data series the words are representative: User experience, Digital transformation, Digital divide, Augmented reality, Supply chain management, Global digitalization, Digital twin, Digital Sensors, Cybersecurity. To avoid repeating terms with the category it belongs to, we eliminated the phrase Digital transformation, and we kept the rest of the terms, as above. Thus, in Digital transformation remains: *User experience , Digital divide, Augmented reality, Supply chain management, Global digitalization, Digital twin, Digital, Sensors, Cybersecurity.*
The words in Fig 4.2.4 b) Sustainability, have the highest frequency on the interval (3.5, 5.34), respectively for this data series the words are representative: Sustainability, Climate change, Circular economy. Similarly, to avoid repeating terms with the category they belong to, we removed the term Sustainability. We completed the following from the list, finally obtaining the terms of the Sustainability category: Climate change, Energy storage system, Carbon footprint.
The words in Fig 4.2.4 c) Industry 4.0, have the highest frequency in the interval (7.85, 40), respectively for this data series the words are representative: Self-assessment, Cloud Computing, Deep learning, Blockchain, Industry 4.0, Internet of things, Machine learning. Similar to the other categories we will remove the term Industry 4.0. We will complete the next one from the list with the highest frequency. Finally the terms will become: Self-assessment, Cloud Computing, Deep learning, Blockchain, Internet of things, Machine learning, Business model.
The words in Fig 4.2.4 d) Employees, have the highest frequency on the interval (10,43), respectively for this data series the words are representative: Coronavirus, Healthcare. It is observed that the frequency of the resulting keywords is influenced by the analyzed period, respectively the years of the Covid pandemic, therefore we will remove these terms, and we will consider the following in order of frequency on intervals for the Employees category: Education, Capability development, Human Centered Computing, Resilience. These terms are much more suitable for our purpose. A series of measures can be linked to them such as staff training, their adaptability, and job reorganization.
It is observed that assumption that the name of the Smart organization includes the above attributes is confirmed, with certain terms with higher frequency being required, as follows:
a) User experience, Digital divide, Augmented Reality, Supply Chain Management, Global Digitalization, Digital Twin, Digital Sensors, Cybersecurity.
b) Climate Change, Circular Economy, Energy Storage System, Carbon Footprint.
c) Self-Assessment, Cloud Computing, Deep Learning, Blockchain, Internet of Things, Machine Learning, Business Model.
d) Education, Capability Development, Human Centered Computing, Resilience.

A visual representation of the above has been made below in Fig. 4.3 Word cloud. We have an overview of the information obtained, of the terms that define the new type of organization.

From the results above, we obtained the following elements from the Quality 4.0 sphere (components, key terms, with the highest frequency identified in the studies in the 3 databases, with the help of which a “Smart Organization” can be built) which we will associate as terms that facilitate transformation, to the new principles enunciated by CQI of Quality 4.0 [C02], grouped in the following categories: Digital transformation, Sustainability, Industry 4.0, Employees.

In the visual representation, in the form of a word cloud below, they are presented as follows in Fig. 4.3, the terms being represented by frequency of occurrence:

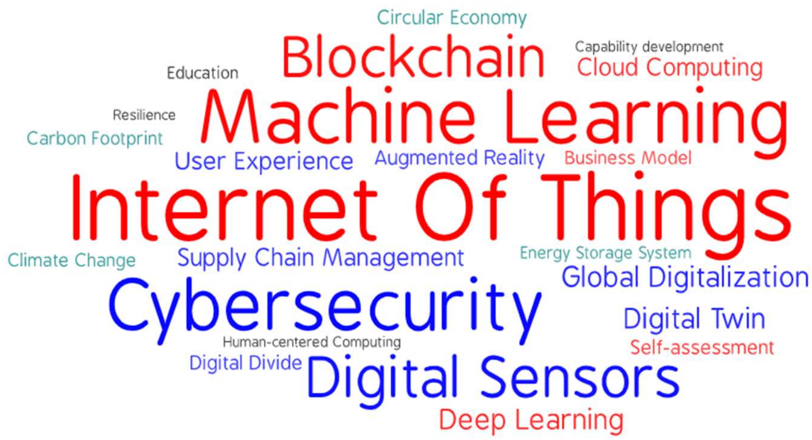


Fig. 4.3 Word cloud view (word cloud)

Legend: The 4 categories are represented by colors: Employees – Purple, Industry 4.0 – Red, Sustainability – Green, Digital transformation – Blue
So we will use these key terms that define the Smart Organization, in our attempt to develop an application to achieve Quality 4.0..

Chapter 5. Research and contributions on the design of the method for transforming the traditional organization into a Smart organization

To meet the Smart organization criteria, an organization must implement actions related to terms in the field of digital technologies and Industry 4.0, consider a sustainable implementation framework, and be flexible so as to adapt to new customer requirements, in close connection with technological evolution.
Consequently, the research and development methodology designed as a reference system for the actions that will be undertaken to achieve the main objective of the doctoral activity, as well as other future developments, must take into account: the Six Sigma DMAIC methodology, as a procedure used to measure processes and improve them [I10], as well as the reference study on a new definition of quality from the summer of 2020 proposed by the CQI (Chartered Quality Institute), together with the assessment of the sustainability of the model based on the WRI (World Resource Institute) GES protocol, the use of the EFQM Model and the realization of an interface (Quality 4.0 application) that determines the extent to which the transformation criteria are met.
Figure 5.1 shows the proposed research and development methodology.

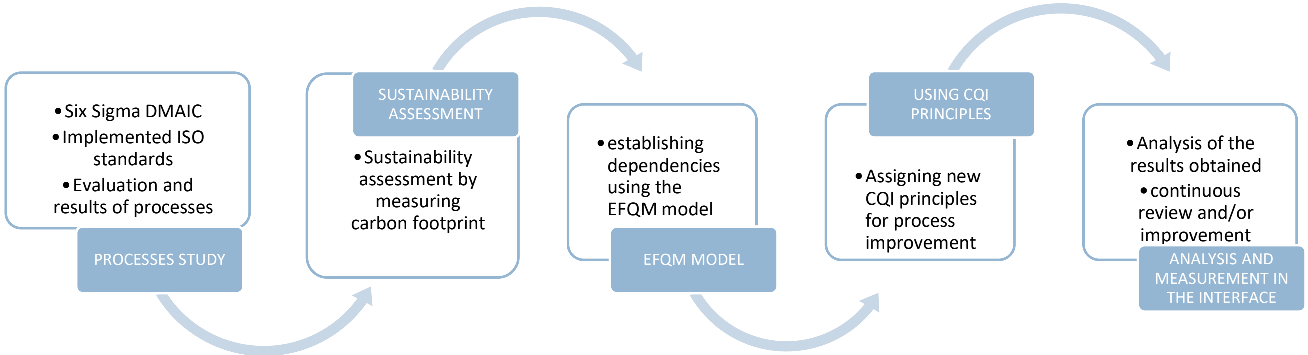


Fig 5.1 Proposed research and development methodology

Starting with 2023, the European Union integrated the DESI (Digital Economy and Society Index) study into a larger project: the State of the Digital Decade report. According to the report, Romania has made notable progress in recent years but has to recover and improve basic requirements in terms of digitalization.
The study in the first two organizations [V02] and [V03], started from the records of customer complaints within the service department, out of the desire to reduce them. Following the analysis carried out by the management together with the author of the study, the following steps were proposed in order to ensure a solution that would provide predictability to the business, a model [Fig 5.3.] and was accompanied by the study in the Service department.

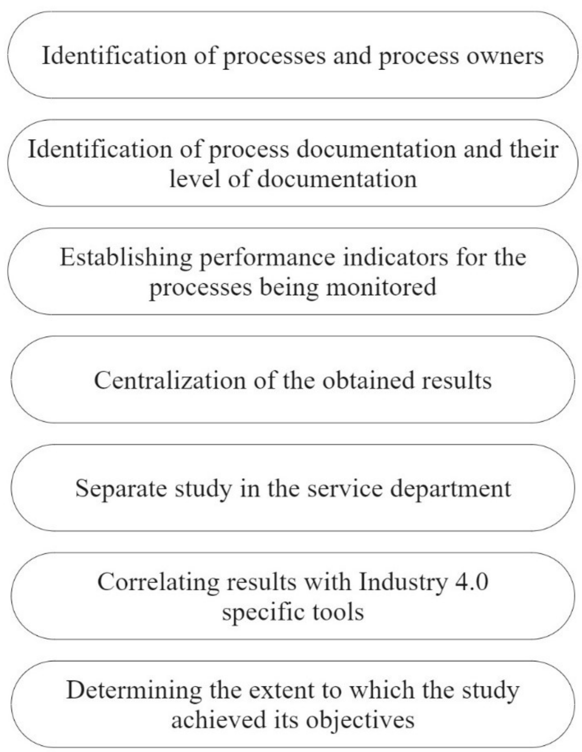


Fig. 5.3 Establishing followed steps to identify a model

In the first study [V02], 10 main processes were identified, and the level of documentation was analyzed for each process. The same procedure was followed in the second study, identifying 6 processes. Qualitative indicators were associated with the identified processes and only those that needed improvement were selected for analysis Table 5.2. In the second similar study [V03], the types of processes were identified, as well as the process indicators, and the measurement period was established similar to the first study. Unlike this, in the first case, a framework similar to the EFQM one was used, namely grouping by criteria of interest. An analysis of opportunities was prepared, and the weaknesses and strengths were determined. In the second study, the application of the Six Sigma DMAIC framework was applied.

Table 5.1 Analysis of processes within the organization

	Documentation analysis		Measurements	
	Weaknesses	Strengths	Weaknesses	Strengths
Management analysis	accessible documents	accomplished	accessibility	accomplished
Policy and objectives	not available	kept under control	cannot be tracked permanently	accomplished
Sales	complaints	are fulfilled	dynamic target (achievement/ planning) average target/ person/ quarter	accomplished
Service	complaints	are not fulfilled	are not fulfilled	archiving
Marketing	missing elements	kept under control	lack of strategies	are not fulfilled
Human Resources, Training and development	accessible documents missing elements	are not fulfilled	cannot be tracked permanently	are not fulfilled
Purchasing	availability	are fulfilled	number of orders	are not fulfilled
Improvement opportunities	accessibility missing elements	are fulfilled	cannot be tracked permanently	are not fulfilled
Risk analysis	difficult to achieve	kept under control	customer interaction with the sales and service department	are not fulfilled
Document and records control	availability	are fulfilled	availability	are fulfilled

Availability – refers to the percentage in which processes exist, are kept under control and are available

Hard to reach (not fulfilled) - refers to the difficult accessibility method, which requires a lot of time for organization, completion, evaluation

Achieving - refers to the fact that it exists, is kept under control, and is available

Partially fulfilled – are only partially available

Unsatisfactory results - the conditions were not met

The analysis resulted in the processes proposed for analysis, as shown in the table Table 5.2

Table 5.2 Critical process analysis with proposed performance indicators

Processes	In	Out	Responsible	Indicator	Verification period
Management analysis	Policy and objectives. Status of corrective actions.	Improvement plan	QMS Resp.	Fulfilment of the policy and objectives - k_{ob}	Biannual
Risk analysis	List of identified risks	Risk register	QMS Resp.	Risk coefficient - k_{risc}	Monthly
Sales	Sales target	Opportunities to improve sales	SR	Sales Performance Indicator - k_{sales}	Quarterly
Service	Service list	List of fulfilled requests	SVR	Performance indicator for dept service - k_{serv}	Monthly
Purchasing	List of purchasing requirements	List of purchasing requirements completed	SPR	Delivery delay indicator - k_{orders}	Monthly
Human Resources	Attendance register	Completed attendance register	HRR	Absenteeism rate -k_{abs}	Monthly
Marketing	Site Visitor Report	Report with analyzed site visitors	MR	Number of website visitors k_m	Quarterly
Opportunities for improvement (Customer satisfaction)	Register of improvement opportunities received from the customer	Register of opportunities for improvement put into practice	QMS Resp.	Improvement opportunities kprop	Monthly

QMS Resp. - Quality Management System Responsible, SR - Sales Responsible, SVR - Service Responsible, SPR – Purchasing Responsible, HRR - Human Resources Responsible, MR- Marketing Responsible

In order to have an overview, it is useful to centralize the performance indicators tracked in both studies and the limits of their classification as in Table 5.3

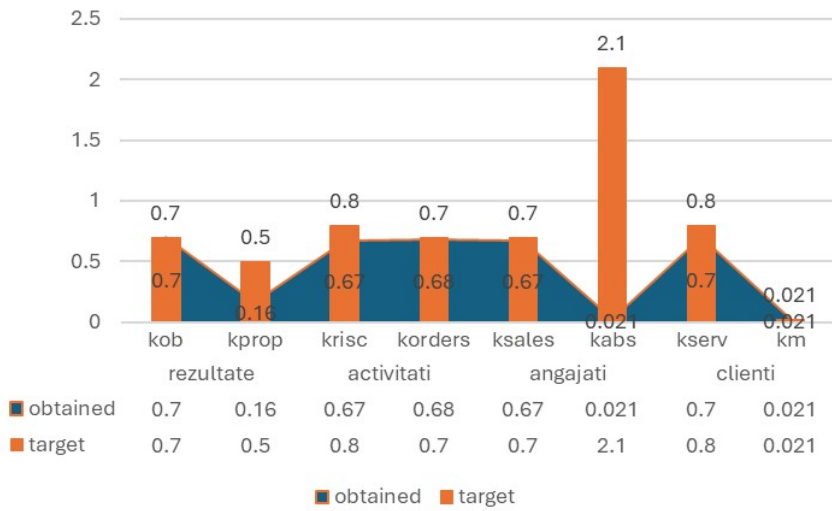
Table 5.3 Limits of the performance indicators analyzed together in 2 studies

Process	Performance indicator	Formula	Limits
Management analysis	Fulfilment of the policy and objectives - k_{ob}	Objectives reached /planned objectives	low ≤ 0.5 medium 0.5 < k_{ob} ≤ 0.7 very good k_{ob} > 0.7
Risk analysis	Risk coefficient - k_{risc}	number of risks kept under control / number of risks identified	low ≤ 0.5 medium 0.5 < k_{risc} ≤ 0.8 very good > 0.8
Customer satisfaction	Improvement opportunities k_{prop}	improvement opportunities for the client/ improvement opportunities	low k_{prop} >1 very good k_{prop} ≤1
Sales	Sales performance indicator- k_{sales}	reached target / proposed target	low ≤ 0.5 medium 0.51< k_{sales} ≤ 0.71 very good >0.71
Service	Service performance indicator - k_{serv}	number of resolved requests / number of requests received	low ≤ 0.7 medium 0.7 < k_{serv} ≤ 0.8 very good >0.8
Purchasing	Delivery delay indicator- k_{orders}	Number of orders received/Number of orders asked	low ≤ 0.5 medium 0.5 < k_{orders} ≤ 0.70 very good >0.7%
Human Resources	Absenteeism rate - k_{abs}	number of absence days / number of days worked per month	low k_{abs} ≤ 0.02 raised k_{abs} > 0.02
Marketing	Number of website visitors k_m	number of closed leads / total number of visits	very good k_{abs} > 0.02 medium 0.01 ≤ k_m ≤ 0.02 low < 0.01

For the service department, the above indicator, service performance indicator k_{serv}, was followed and an analysis was performed in both cases.

By collecting data from both studies and comparing them, the following overview was obtained in Table 5.4.

Table 5.4 Centralization of performance indicators tracked together in the 2 studies



It is observed that some of the specified performance indicators are close to the targeted limits while for another part it is necessary to pay additional attention in order to achieve the pre-established objectives and take measures to improve them. In both organizations, customer repair requests were analyzed, and the main types of defects were selected, then they were divided into 3 large types: major, medium and minor defects. The method applied was similar in both organizations. In the next step, we conducted a risk assessment, similar for the 2 organizations. It is observed that the following types of defects that occur most often, reported by customers of both organizations are in the hydraulic system, electrical, mast, braking system, fluid losses as well as in the engine system.

The 5 Whys method was then applied to identify common causes of defects and to increase the productivity indicator in the k_{serv} service. Similarly, the Pareto method can be used to identify defects related to most service requests. After detecting the main causes leading to the most service requests, the interdepartmental team together with the author prepared a special form for use by forklift owners.

Subsequently, the implementation of the above measures led to the improvement of the organization's processes, however, to achieve the proposed target, additional measures are necessary.

A plan with proposals for process improvement was developed and each process was correlated with at least one Quality Principle 4.0 as seen in Table 5.11. (new principles stated by CQI)

Table 5.11 Correlating results with Industry 4.0 specific tools

Principle Q 4.0 / The process	**P1** Added value	**P2** Vertical and horizontal information recording	**P3** Vertical and horizontal information recording	**P4** Automation	**P5** Mutual trust in system compliance and data use	**P6** Adaptive learning	**P7** Data is a strategic asset	**P8** Data is a strategic asset
Policy and objectives k_{ob}	x							
Risk analysis k_{risc}		x						
Customer satisfaction k_{prop}		x						
Sales k_{sales}	x			x				
Service k_{serv}		x			x			
Purchasing k_{orders}						x		
Human Resources k_{abs}								x
Marketing k_m	x							

Thus, the author together with an interdepartmental team established proposals based on solutions in the field of digital technologies as can be seen below:

I. Process: Policy and objectives , indicator k_{ob}
Proposal/objectiv: increasing the degree of achievement of policy and objectives k_{ob} ;
Proposed target: k_{ob} >0.7;
Proposed solution: must be in the Added Value area, namely principle 1, in this area being a need for improvement. Therefore, developing a system/program in which the degree of achievement of the policy and objectives can be tracked and measured at any time is indicated.
Responsible: QAS Manager
Due date: 6 months.

II. Process: Risk analysis k_{risc}
Proposal/objectiv: improving krisc
Proposed target: $k_{risc} > 0.8$
Proposed solution: it is located in the area of Principle 2, respectively, data recording must be continuously evaluated, there must be transparency regarding the data held. Increasing awareness of existing risks among those involved in the process. It is necessary to provide tools to keep up with customer requirements regarding their data.
Responsible: QAS Manager
Due date: 1month.

III. Process: client satisfaction: k_{prop}
Proposal/objective: improving quality satisfaction k_{prop}
Proposed target: $k_{prop} \leq 1$
Proposed solution: within the scope of Principle 2, recording data horizontally but also vertically. It is proposed to record customer proposals within any department. Improvement tools should follow customer requirements and consider customer feedback, possibly a cloud-accessible solution.
Responsible: QAS Manager
Due date:1 month.

IV. Process: Sales k_{sales}
Proposal/objective: improving k_{sales}
Proposed target: $k_{sales} > 0.7$
Proposed solution: in the area of Principle 1, The added value of Principle 4 and offering easily accessible services by the customer. Creating a fast communication interface between the customer and the seller with the possibility of remote access in the cloud;
Responsible: QMS Director and Sales Manager
Due date: 3 months

V. Process: Service k_{serv}
Proposal/objective: improving k_{serv} indicator
Proposed target: $k_{serv} > 0.8$
Proposed solution: the proposed solution is in the area of Principle1 Added Value. It is proposed to create an interface between the client and the supplier for more efficient service scheduling. It is also advisable to prepare a separate study on how it was done in both cases.
Responsible: QAS Manager and SVR Service Responsible
Due date: 1 month

VI. Process: Purchasing k_{orders}
Proposal/objective: increase k_{orders} coefficient
Proposed target: $k_{orders} > 0.7$
Proposed solution: The proposed solution is within Principle 6, to ensure predictability depending on the period
Responsible: QMS Director and SPR Purchasing Responsible
Due date: 1 month

VII. Process: Human resources k_{abs}
Proposal/objective: improving K_{abs} coefficient
Proposed target: $K_{abs} > 0.02$

Proposed solution: around Principle 8, namely technology and intelligence combined. Flexible solutions for cloud working and remote work must be offered given the situation generated by the COVID pandemic and consider the rate of absenteeism.
Responsible: QMS Director and HRR Human Resources Responsible
Due date: 1month.

VIII. Process: Marketing k_m
Proposal/objective: improving k_m coefficient
Proposed target: $k_{m\ >1}$
Proposed solution: is in the area of Principle 1, Added value for the customer, so that more customers and visitors can be attracted to the site. Online marketing strategies must be promoted and promotional tools created in the virtual environment.
Responsible: Marketing Responsible
Due date: 1 month.

Following the study conducted within the stacking organizations, positive results were obtained and the validation of the method by applying it within another organization was sought, but also to demonstrate its efficiency.
For ease, it was proposed to develop a tool in order to optimize the processes of organizations. It was desired to improve workflows by implementing actions that would allow real-time tracking of activities, easy recording of events, obtaining reports related to the organization at any time and at the same time, these would not lead to overloading the activity or to blockages in the activity, but rather to produce its efficiency.
To achieve the above, a similar study was undertaken to confirm the efficiency of the results obtained from the first study.
In order to achieve the proposed objective, an interdepartmental team was formed, consisting of the heads of each department, who together with the author of the study, using the method applied in the previous study, synthesized the following key aspects at the start of the organization's analysis process and which constitute the Definition phase.
In the measurement phase, the following were scored and achieved, according to the previous model:
The degree of fulfillment of the objectives pursued kob from the Analysis carried out by management was measured. The aim was to improve the results obtained in the previous measurement. There are 25 criteria to be fulfilled, and each of them was given a score as follows depending on the degree of fulfillment as in Table 5.12, and then the weighted average was calculated (9)

$$k_{ob} = \frac{5x12+3x4+2x9}{24+8+} = 3.6 \quad (9)$$

Table 5.12 Degree objectives' achievement

Objective	Degree of achievement of the objective					Improvement indicator	Process
	5	4	3	2	1		
Quality is each person's task				x		Number of missing items/ total number of inventory items k_L	Purchasing
Optimal quality/price ratio				x		Average time to produce a piece of equipment $k_{delivery}$	Sales
Customer and regulatory requirements followed				x		Project efficiency k_P	Design and Development
Competent employees				x		Satisfaction level measurement/employee k_{as}	Human Resources
Diversifying marketing activities				x		Click rate conversion k_v	Marketing
Product upgrades				x		Average production cost / product k_{CMT}	Design and Development
Monitoring non-conformities				x		Number of non-conforming products delivered/ total number of products delivered k_A	Purchasing
Improving internal communication	x					-	Human Resources
Employee performance management system			x			-	Human Resources
Training employees to make compliant products				x		Non-conformities reduction k_{Nlunar}	Production
Customer satisfaction rating				x		Ratio between interventions claimed by the customer under warranty / total interventions k_{serv}	Service
Transition to ISO45001	x					-	Director SMCMSSM Manager

Training employees to prevent illness			x			-	Director SMCMSSM Manager
Compliance with OSH legislation in the organization			x			-	Director SMCMSSM Manager
Improving working conditions			x			-	Director SMCMSSM Manager
Mandatory annual health check	x					-	Human Resources External
Providing protective equipment	x					-	Director SMCMSSM Manager
Implementing measures after risk assessment	x					-	SMCMSSM Manager Human Resources
Preparing employees for the emergency response plan	x					-	SMCMSSM Manager
Organizational culture regarding environmental protection	x					-	Human Resources
Compliance with environmental legislation	x					-	Human Resources SMCMSSM Manager
Improving waste management	x					-	SMCMSSM Manager Production
Development of services with low environmental impact	x					-	Design and Development
Partnerships with suppliers in the field of environmental protection	x					-	Director SMCMSSM Manager
Reduction of energy consumption per unit of product	x					-	Design and Development

Legend: 5- excellent, 4 - very good, 3 - good, 2- unsatisfactory, 1- not good (week)

This value obtained for k_{ob}, is better than that obtained in the previous analysis k_{ob1}, respectively: $k_{ob1} = 2$, but lower than the proposed target: $k_{ob} > 4$.

Indicator k_{ob}	week $k_{ob} <2$ medium $\leq k_{ob} \leq 4$ very good $k_{ob} > 4$

In the Analysis phase, in order to improve the result obtained, nine indicators were selected where the most complaints were registered, the responsible processes, the most improvement proposals and the lowest values of the performance indicators were identified, as starting points for improvement.

Sales - $k_{delivery}$ Indicator

Next, the improvement limits were configured based on the previous results and those obtained, using the data collected during the research, regarding the production time of the top five best-selling equipment: single-phase transformers, three-phase transformers, three-phase rectifiers, three-phase network coil, distribution box.

Interpreting $k_{delivery}$

Indicator $k_{delivery}$	week: $k_{delivery} < 12$ medium: $12 \leq k_{delivery} \leq 14$ very good: $k_{delivery} > 14$

The aim is to improve the result obtained: $k_{delivery} < 12.5$ days

Marketing - k_{vm} Indicator

Interpreting k_{vm}

Indicator k_{vm}	very good: $k_{vm} > 0.5$ medium: $0.2 \leq k_{vm} \leq 0.5$ week: $k_{vm} < 0.2$

The target is to obtain a better quarterly indicator, respectively $k_{vm} > 0.5$ %

Service - k_{serv} Indicator

Regarding the Analysis of the Service and Repair process, an initial analysis was carried out within the department followed by a separate study.

Interpreting k_{serv}

Indicator k_{serv}	very good: $k_{serv} < 0.5$ medium: $0.5 \leq k_{serv} \leq 0.9$ week: $k_{serv} > 0.9$

The main defects were centralized, and the average cumulative frequency of defects was calculated and then Pareto analysis was performed as in Fig 5.6

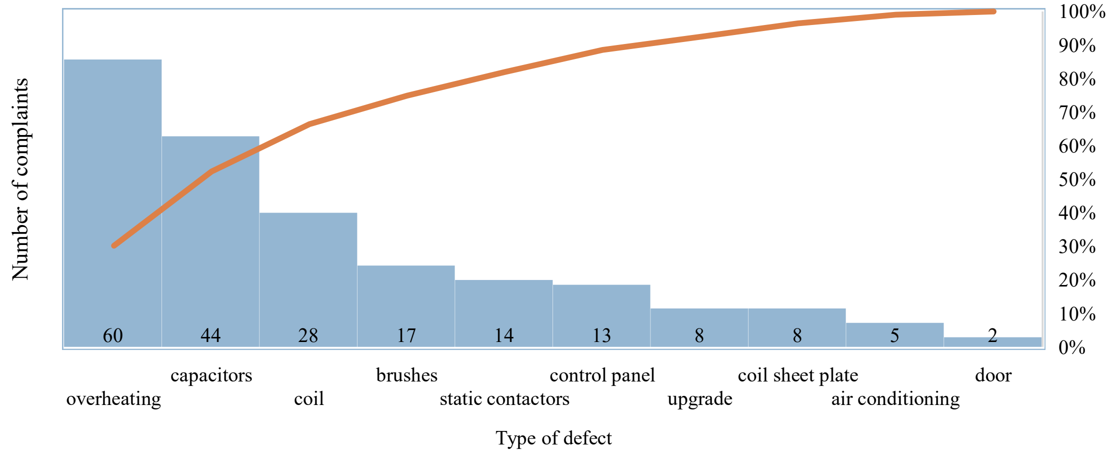


Fig 5.6 Pareto analysis

It was observed that the first two types of problems are responsible for the most complaints: overheating and condensers. Considering the objectives pursued: to reduce service requests by half, reduce the number of complaints, improve customer satisfaction but also avoid overcrowding in the department, we applied the 5Whys method to identify the causes of the main defects.
In order to improve customer satisfaction and to reduce the number of service complaints, a monthly customer check sheet of the equipment described above was proposed.

Purchasing – performance indicator of supplied products k_A
Interpreting k_A:

Indicator k_A	very good: $k_A < 0.1$ medium: $0.1 \leq k_A \leq 0.3$ week: $k_A > 0.3$

Performance indicator k_L of **inventory products**
Interpreting k_L:

Indicator k_L	very good: $k_{serv} < 0.02$ medium $0.02 \leq k_{serv} \leq 0.05$ week: $k_{serv} > 0.05$

Design and Development

Project efficiency

Indicator k_P	very good: $k_P < 0.18$ medium: $0.18 \leq k_P \leq 0.2$ week: $k_P > 0.2$

Average production cost/product
Target is $k_{CMT} < 0.28$

Production
The aim is to improve on the result obtained, therefore the result sought k_N monthly <0.17.

Human resources
A measurement of employee satisfaction was proposed in order to establish starting points for improving work productivity and increasing their retention in the organization using a questionnaire with 4 measurement criteria: salary, career, work environment, training, on a Likert scale rated from 1-5 (very satisfied-5 points, satisfied-4 points, acceptable-3 points, dissatisfied-2 points, very dissatisfied-1 point).
The goal is k_{as}>3.86 . The results obtained were then centralized.

Improvement Phase
The actions taken aim to improve customer satisfaction and the creation of added value for them, reducing costs, but also gaining a competitive advantage over the competition through digitalization. Having an image of the organization and what it wants to achieve (the target it wants to reach), it was possible to associate at the level of each critical point found, where improvement is needed, methods from the field of digital technologies, in line with the new Quality 4.0 vision and with the study conducted by CQI from which we started. It was intended to ensure sustainability with the activities carried out within the project.
The plan with the improvement proposals and associated measures from the scope of the principles stated above, was developed in Table 5.25 Improvement proposals
The results are measured again at a set interval, and it is observed to what extent those proposed in the previous phase were fulfilled.

Table 5.25 Improvement proposals

Name	Process	Quality 4.0 principle	Term	Improvement measure	Responsible	Performance measurement
k_{ob}	Management analysis	**P1**	Biannual	Creating a calendar in your email program with deadlines and responsibilities and tracking fulfillment.	Director SMCSSM Manager	k_{ob} > 4
$k_{delivery}$	Sales	**P6** **P2**	Monthly	Using a rapid learning system to take the necessary and analyze it with suppliers to find the optimal time solution for project completion and transparency in the relationship with the client	Director SMCSSM Manager	$k_{delivery}$ < 12

k_{vm}	Marketing	**P1** **P2**	Quarterly	Use a program to measure the site pulse (Tidio)	Marketing Responsible	$k_{vm} > 0.5$
k_{serv}	Service	**P1**	Monthly	Reducing the number of service complaints by using a customer equipment evaluation form	Responsible Service	$k_{serv} < 0.5$
k_A	Purchasing	**P3**	Monthly	Its supplier evaluation report, score regarding compliance with requirements	Purchasing Responsible	$k_A < 0.1$
k_L	Purchasing	**P1** **P7**	Monthly	Identifying milestones in the manufacturing flow based on QR codes from entering the organization, to finished products, and until leaving the organization	Materials warehouse Responsible	$k_L < 0.02$
kp	Design and development	**P3**	Quarterly	Compliance with the prescriptions issued by the authority in the field	Design and development Responsible	$k_P < 0.1$
k_{CMT}	Design and development	**P8**	Quarterly	Creating product models with cloud-based benchmark options and using them to verify an optimal solution for pricing and delivery time	Cost analysis Responsible	$k_{CMT} < 0.2$
k_{Nlunar}	Production	**P1**	Monthly	Cloud-based solutions for easy tracking of work instructions and biometric marking of each operation	Production manager and executive staff	$k_{Nlunar} < 0.1$
k_{as}	Human resources	**P4**	Annual	Implementing software solutions to automate certain repetitive office tasks	Production manager and executive staff	$k_{as} > 4$

After implementation, the indicators were measured and analyzed as in Fig 5.13

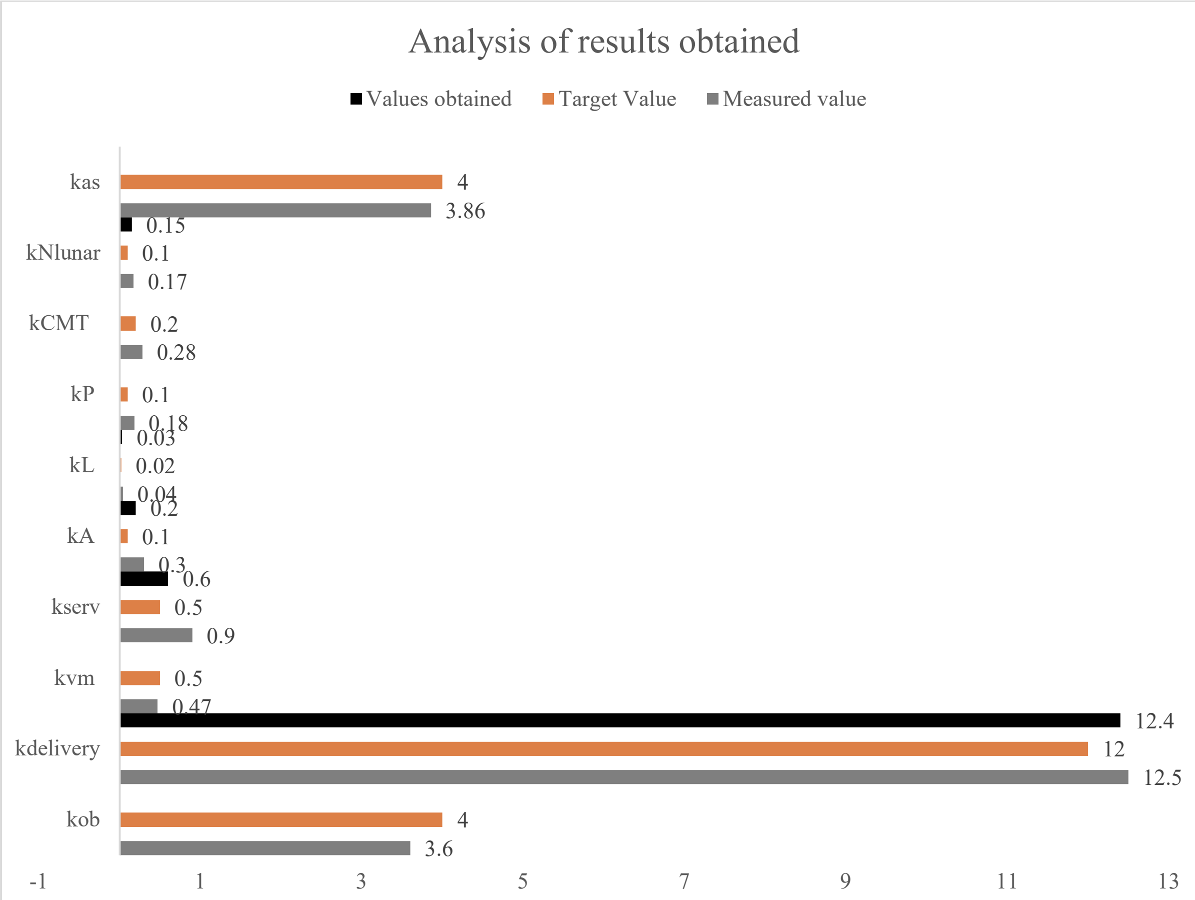


Fig 5.13 Analysis of results obtained

From the graph obtained above, a slight improvement is observed where it was possible to evaluate.

Control phase

The final phase, control, follows. After achieving the proposed results, the organization continues to monitor the process. If the objectives are not met, the procedure is repeated until the desired results are obtained.

As noted above, an improvement model was formulated for processes considered underperforming using the Six Sigma methodology and the classic DMAIC principle, but implementing technologies such as Big Data, Cloud Computing, ML, IoT, Additive Manufacturing, etc. The proposed method has the advantages of using established quality improvement techniques, namely the DMAIC principle as well as the approach to digital technologies. The solutions were implemented, and we ensured that the method ensures progress.

The new trends of transformation and transition to Industry 4.0 require organizations to be driven towards digital transformation and the integration of the Quality 4.0 concept. The result of the two studies will be the creation of an application so that a management model can be easily obtained and followed to ensure continuous improvement of the organization's performance.

Chapter 6. The sustainable perspective of the process improvement method for the purpose of transforming into a Smart organization

To establish the greenhouse gas emissions inventory, the following steps were identified as shown in Fig 6.1

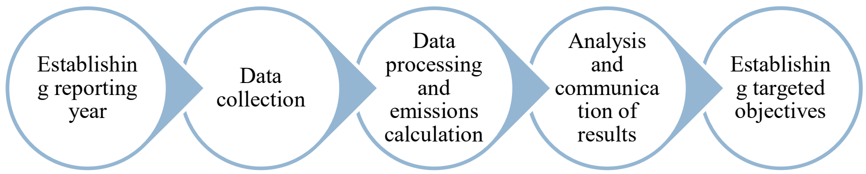


Fig 6.1 Steps for establishing a greenhouse gas emissions inventory (GHG)

To establish the carbon emissions inventory, emissions were classified according to their purpose.

To establish the reporting year, it was considered that the data analyzed at that year level should be available, complete, reliable, and the time period should be as close as possible to the year of the analysis. Data was collected and centralized on sources with an overwhelming role in GHG emissions (greenhouse gases) both upstream and downstream, data on the components that enter the organization's production (e.g. elements that enter the composition of commercial goods produced by the organization)

The consumption related to Purpose 1 and 2 for the period 2019-2022 is in a slight downward trend, the organization carefully monitoring its greenhouse gas emissions, however, in order to achieve the targets proposed by the EU, the organization must manage them more efficiently.

After centralizing the results, the following overview of the organization was obtained as in Table 6.4

Table 6.4 Evolution of annual energy consumption, by categories

	SCOPE 1	SCOPE2	
	Gas (m^3)	Petrol (l)	Electrical energy (kWh)
2019	11926	11461	116700
2020	11645	11488	106800
2021	16974	13338	81900
2022	7267	11362	62100

In the third phase of processing and calculating emissions data, the approach according to chapter 5.4 of the ISO 14067:2018 standard [I13] was used to determine the carbon footprint. Where data were not available, we used the standard, reference, or zero value. Since data were available in different units of measurement, they were converted in order to finally calculate the consumption of carbon dioxide equivalent CO_{2e} emissions. The conversion factor of carbon dioxide equivalent CO_{2e} emissions converts data from activities into CO_{2e} emissions. The coefficients in this study relating to emissions and emission factors are those reported by the UK government, cross-sector [D05] aligned with the standards set by the Intergovernmental Panel on Climate Change (IPCC Report No. 5) [I14]

$1m^3$ gas-10.7 kWh (depending on the calorific value of the gas. In our case we used the indications on the invoices)

1 kWh = 3,6 MJ

1l petrol = 13.13 kWh= 47.3 MJ

The carbon footprint is measured in units (tons) of carbon dioxide equivalent. CO_{2e}.

CF (Carbon Footprint) = AD (Activity Data) x EF (Emission Factor) (tons of emissions per unit / year) (19)

CF = Carbon Footprint

AD = Activity Data

In Table 6.5 the GHG inventory was calculated, CO_2 emissions were calculated as well as consumption in [kWh] based on available data.

Table 6.GHG Inventory

	Petrol Consumption	*) CO_2 emissions conversion factor	Emissions	Consumption	Gas Consumption	**) CO_2 emissions conversion factor	Emissions	Electrical energy Consumption	Electrical energy	***) CO_2 emissions conversion factor	kg CO_{2e}	Consumption
UM	l/an	Kg CO_2 / l	Kg CO_{2e}	kWh	m^3/an	m^3/Kg	kg CO_{2e}		kWh	Kg		kWh
2019	11461	2.30	26360.3	120087.78	11925.98131	2.026	24162.03813	127608	116700	0.00061	71.187	127608
2020	11488	2.3	26422.4	120370.57	11644.95327	2.018	23499.5157	124601	106800	0.00061	65.148	124601
2021	13338	2.33	31077.54	124142.34	169739.9065	2.017	342365.3915	1816217	81900	0.00061	49.959	1816217
2022	11362	2.32	26359.84	105750.99	7267.009346	2.011	14613.95579	77757	62100	0.00061	37.881	77757

*) established based on UK annual report data
**) established based on UK annual report data
***) established based on the invoice data issued by the supplier

During the studied period, the evolution of emissions related to Scope 1 as well as emissions related to Scope 2 were analyzed to see the evolution of the main types of consumption, as shown in Fig. 6.5.

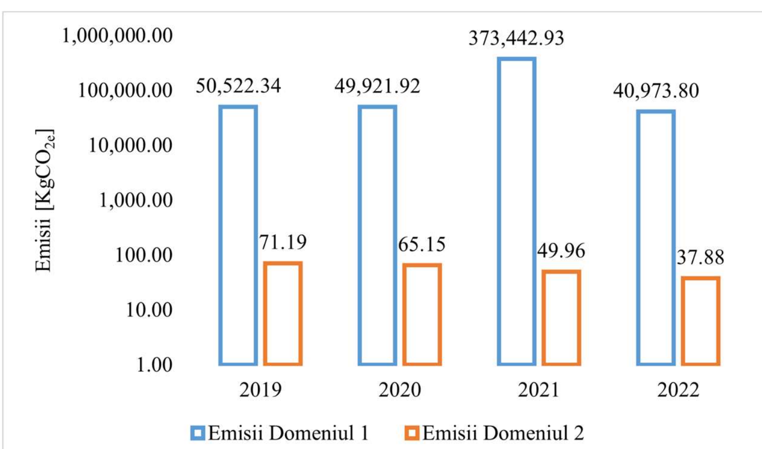


Fig. 6.5 Emissions analysis over time Scope 1 and Scope 2

For 2020, Scope 1 emissions recorded the lowest level, and for 2021, the highest level of Scope 1 emissions was recorded. For 2022, although there was a gradual recovery, lower consumption was observed than in all three previous years analyzed, against the background of the increase in the organization's turnover and implicitly the increase in the number of orders and activities resulting in an active involvement of the staff in terms of their role in reducing emissions. An annual inventory of total emissions can be calculated as in Fig. 6.6 to obtain the organization's carbon footprint. According to Regulation (EU) no. 601/2012 of the European Commission consolidated, within the document General Guidelines on installations at the organization level depending on the amount of emissions generated, they fall into category A (average annual emissions are less than or equal to 50,000 tons of CO2e), Category B (average annual emissions are greater than 50,000 tons of CO2e but less than or equal to 500,000 tons of CO2 CO2e) or Category C (average annual emissions are greater than 500,000 tons of CO2. The analyzed organization with an average annual consumption below 50,000 t falls into category A.

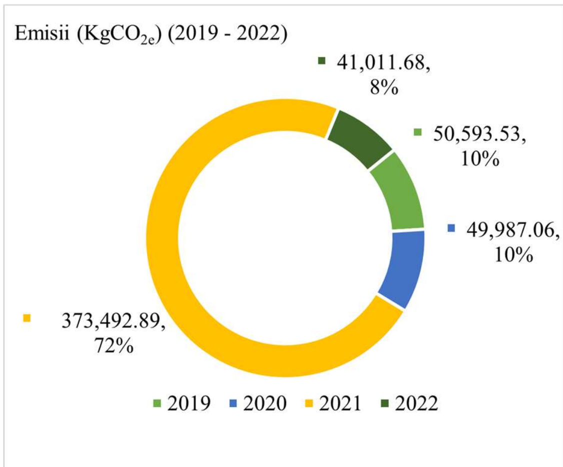


Fig. 6.6 Annual carbon emissions 2019-2022

The organization falls into category A, up to 50,000 tCO_{2e}/year. In order to reduce carbon emissions, the organization has set itself the goal of implementing a series of measures in its policy, as well as establishing a chapter within the organizational culture that would encourage staff to carry out activities that would lead to a decrease in its CO_2 footprint: using bicycles, public transport, recycling, using economical lighting solutions, using local products, not using heating/cooling systems excessively.

In conclusion, the study conducted proved to be a useful tool for the organizations presented, so that first of all it helped implement a method to improve processes and ensure their transition to digital organization status, all within a sustainable framework by reducing their carbon footprint.

In this regard, measures such as reducing the use of paper in the organization's activities until its elimination have been considered for future implementation. Similarly, the use of natural gas has major disadvantages, so it is known that incidents with a negative effect on the environment may occur during extraction. At the same time, it is a limited resource and through use, during combustion, greenhouse gases are released into the atmosphere that contribute to global warming. However, special attention must be paid to this, because in the desire to achieve a zero-carbon economy, it is possible to affect other sectors and pollute in other ways.

Chapter 7. Application development Tool for improving organizational processes: *Quality 4.0*

The development of the Tool for improving the processes of Quality 4.0 organizations is based on the methodology proposed in the Eelisa Digitall4 PPP (People Planet Performance) Workshop 23 - 24 November 2023, as well as May 2025 and follows the logic diagram in Fig. 7.1 Steps for implementing the proposed model, established based on previous studies. Thus, using the components of the EFQM model, the final result is an easy-to-implement tool in small and medium-sized organizations in Romania. From the previous chapters, the following steps result for transforming an organization into a Smart organization:

7.1 Initial measurement of processes. Steps for implementing the proposed model. Steps for developing a Quality 4.0 application.

In our approach to transforming an organization into a Smart organization, the steps in Fig. 7.1 (following Chapter 5 and Chapter 6) for implementing the proposed model result.

In a similar way, in the form of a table or graph, after centralizing the data, in the application, it will be possible to assess, as in Fig. 7.2, to what extent the organization has implemented the proposed measures, depending on the number of measures completed in total, as follows:
0 - Start (start) has not yet been measured, or nothing has been completed;
5/10 - Requires analysis/reanalysis - respectively, after implementation and measurement, the indicators need immediate attention and action. In our case, there were performance indicators that are measured every six months, so it was not possible to decide, since the measurement was not available for some of them, they were considered to be still under evaluation (five improvement measures out of 10 were achieved, so over half);
4/10 - On target - after implementation and measurement the indicators are improved compared to how they were before, but have not yet reached the target (four indicators out of 10 remain)
1/10 - Very good - after implementation and measurement the indicators are better or have even reached the target. (at least nine out of 10 measures have been met or all)

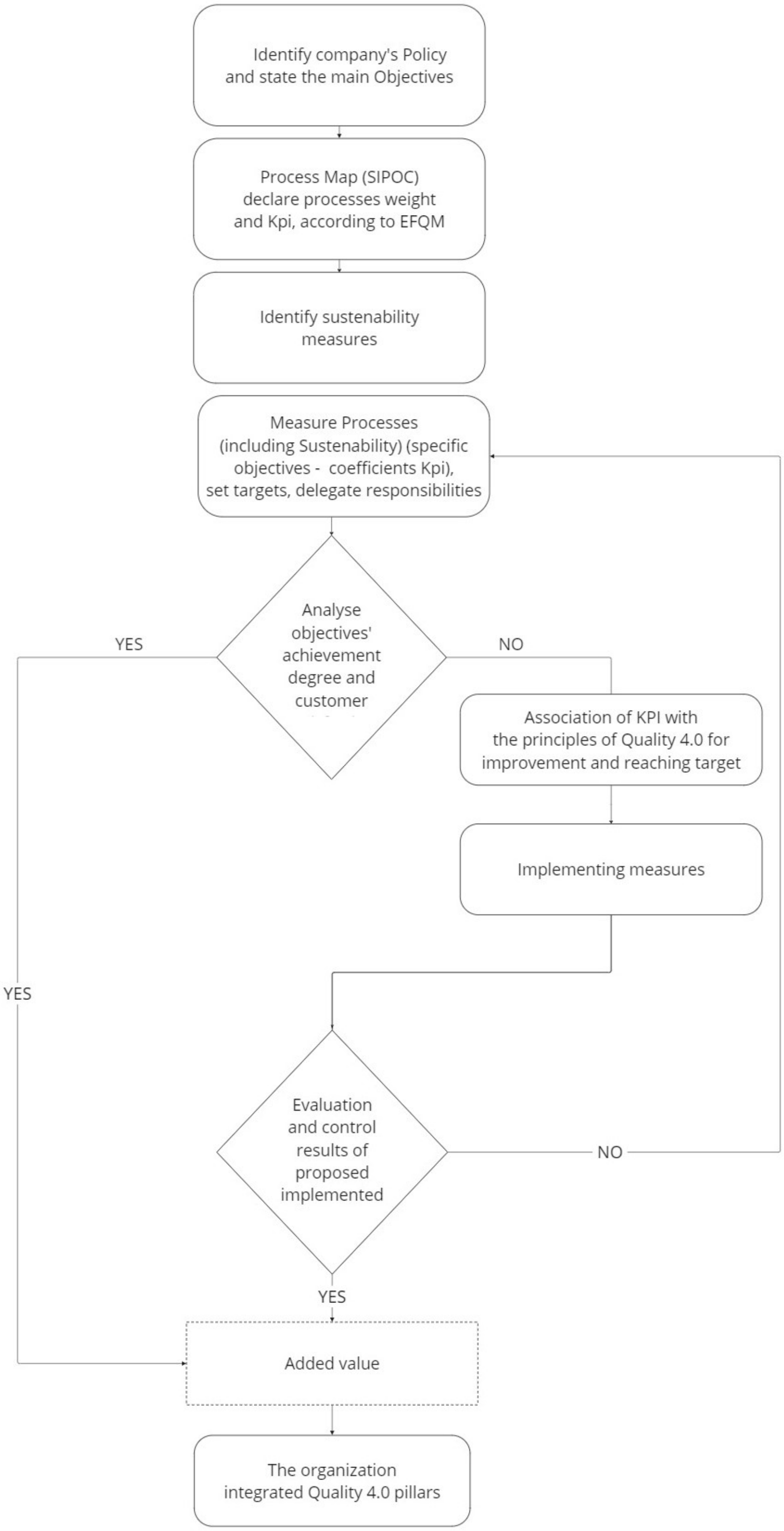
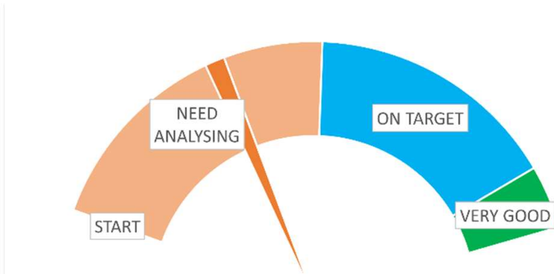


Fig. 7.1 Steps for implementing the proposed model



0	Start	
5/10	Requires analysis	
4/10	On target	
1/10	Very good	

Indicator name	Indicator decision Kpi
k_{ob}	Requires analysis
k_L	Very good
$k_{delivery}$	Very good
k_P	Requires analysis
k_{as}	Very good
k_{vm}	Very good
k_{CMT}	Very good
k_A	Requires analysis
k_{Nlunar}	Requires analysis
k_{serv}	Requires analysis

Fig. 7.2 View results obtained

7.2 Initiating the development of the Quality 4.0 application interface

For the purpose of permanent monitoring and for more efficiency in use, it is necessary to develop an application that provides a physical interface to the proposed methodology. The future Quality 4.0 application will be dedicated to small organizations which want to innovate, following the new definition of quality Quality 4.0. Next, the development of the interface design and functionality of the Quality 4.0 application was carried out and contains the following elements:

- **a login section (Login)** and a password reset section (Forget password) for users Fig 7.3 a

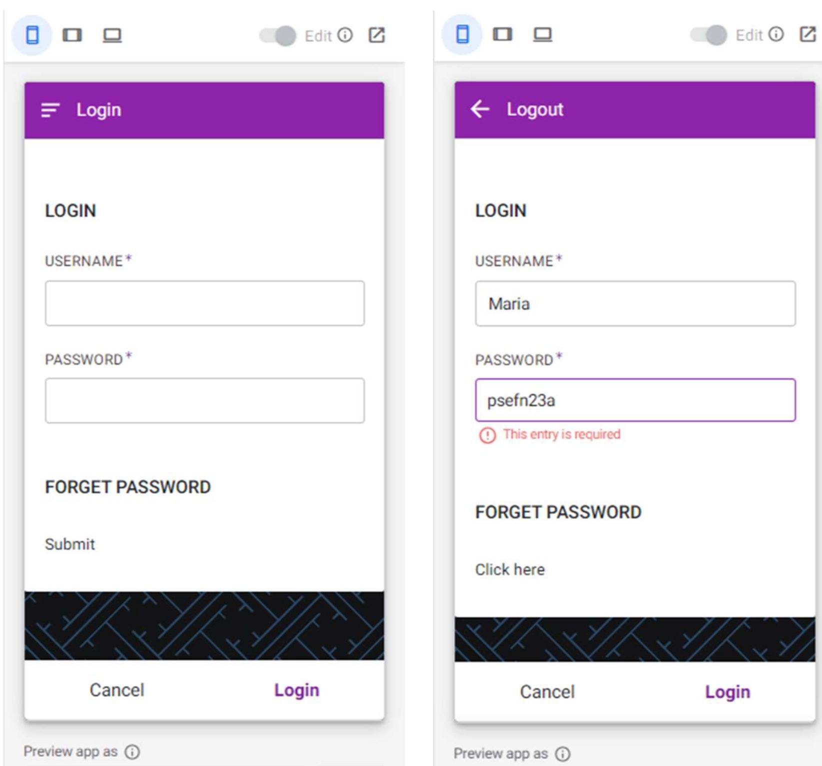
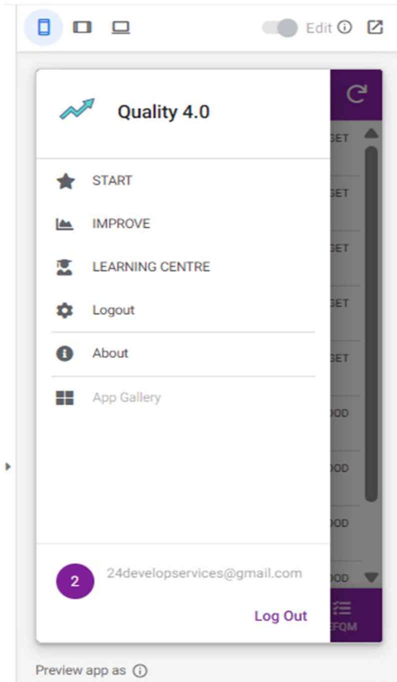
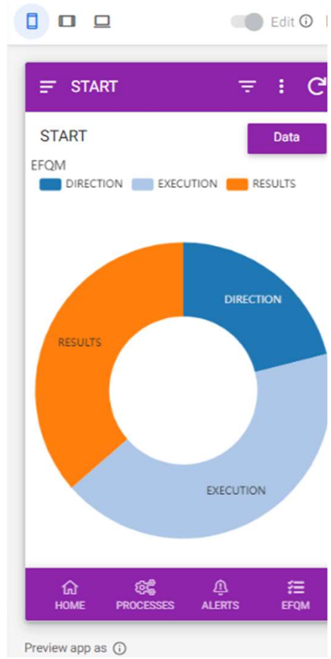


Fig 7.3 a Quality 4.0 App interface design (login section)

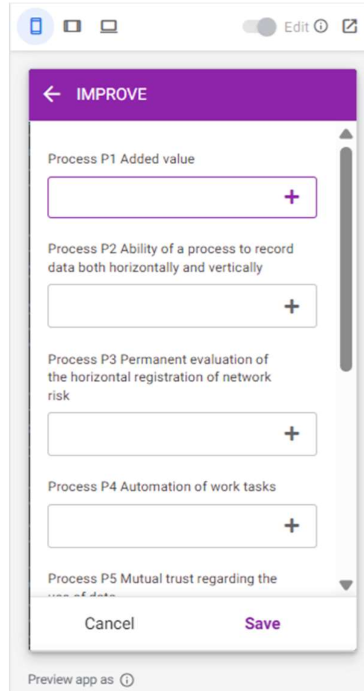
- **menu-type section**, on the left, where you will find the main fields of the application, respectively: Start, Improve, Learning centre, Login, About as in Fig 7.3 b



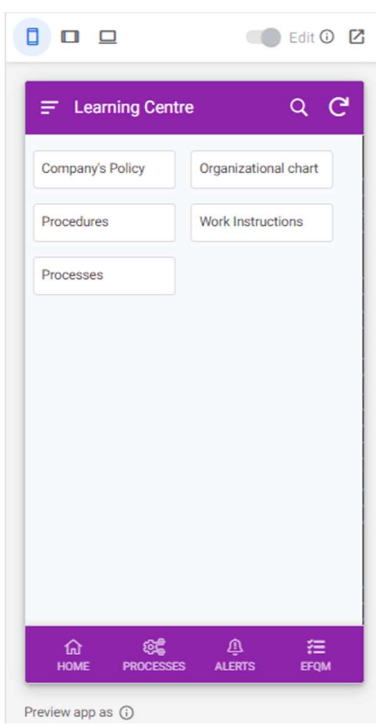
App Menu



Start



Improve



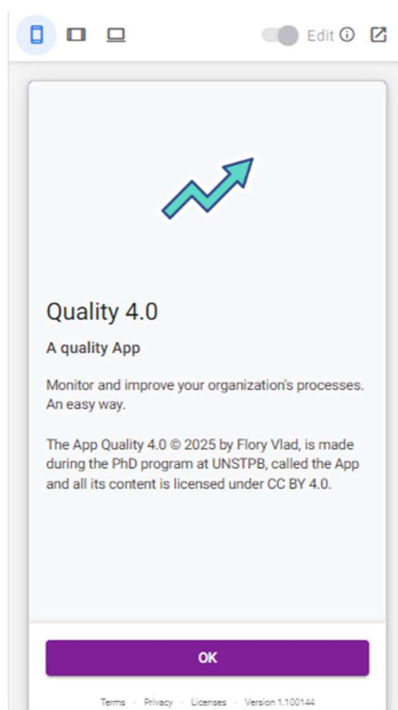


Fig 7.3 b Quality 4.0 App Menu

Start - centrally displays the status of the organization, in the form of a donut graph, respectively the score according to EFQM criteria, based on data obtained from the organization's available situations and available in the cloud.
Improve – displays a list of options from the Quality 4.0 sphere that can be selected and proposed to be carried out by designated personnel in order to improve the organization's processes. The list of operations is sent by email.
Learning centre – is part of the organization's knowledge management. Here you will find instructions, procedures, and processes.
Login / Logout - login/logout section required for entering/exiting the application.
About – application information.
Conclusions can be drawn on what measures need to be taken for improvement, in which area, and which actions can be attributed. The proposed improvement actions were chosen from a variety of existing potential suggestions and were associated with the unmet target indicators. The procedure is repeated until the desired results are achieved..

- a **dashboard section** (dashboard) in which the following elements are found: Home, Processes, Alerts, EFQM as in Fig 7.3.c. In the Alerts section, the kpi indicators and the values of the indicators resulting from the processes will be found. For each kpi performance indicator, the stage it is in after the evaluation will result and a general conclusion can be obtained. Thus, a graph indicating the state of the organization after measurements will result at the end and the indicators that require improvement can be observed.

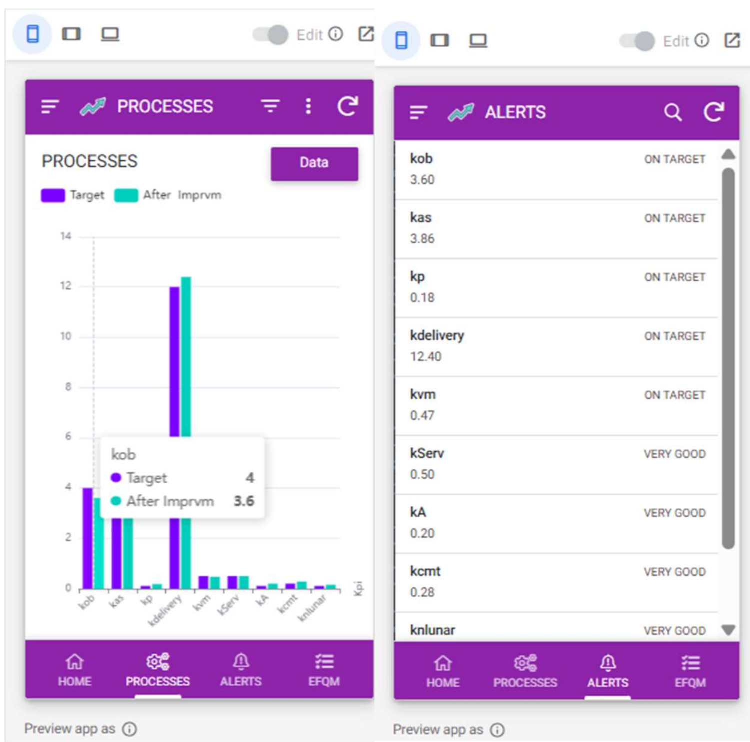


Fig 7.3.c Dashboard section

7.3 Application backend content Quality 4.0

The Quality 4.0 application in the backend will have attributes corresponding to the 8 principles stated by CQI, taking from the analysis of the EFQM 2020 model, the part related to the criteria that an organization must meet to achieve excellence. So similarly we adopted the criteria on which the evaluation is based, also using the RADAR chart as in Fig 7.4 for the overall, holistic evaluation of the organization at any time.

Fig 7.4 Analysis of indicators measured after improvement based on criteria EFQM

From the Radar chart in Fig. 7.4, the following can be observed: each process was measured and the performance indicators on which it is evaluated provide indications of improvement. However, where measurement was not possible, as it was carried out at different intervals from those analyzed, the last available values, usually the previous ones, were used to have a picture of the organization at any time.
The processes achieved increases, therefore the implemented methods yielded results.
The steps were as follows:

- each process related to the 3 EFQM directions is measured after improvement
- depending on its importance, it is assigned the corresponding score
- the percentage difference required to reach the target % is calculated, respectively to obtain the maximum score: ABS(Target-Value after improvement)/ Improvement value *100
- a graph similar to the RADAR graph is drawn up with the two measurements (target and the one after improvement)
- the evolution of the system after the improvement is assessed, conclusions are drawn if the evolution falls within the target pursued

The interface of the application to be created will follow the above principle, as well as the logic diagram in Appendix A, attached at the end of this paper.

Chapter 8. Thesis conclusions and contributions regarding process optimization from an Industry 4.0 perspective

8.1 Thesis conclusions

This doctoral thesis, through its issues, approach and results, develops a new method for improving processes in accordance with the Quality 4.0 concept and current technologies that help implement it in organizations.
With the help of the studies carried out and by developing the Quality 4.0 application, based on the previous chapters, elements of Industry 4.0 and its applications that were aligned with the proposed methodology (Chapter 5) were used to achieve the main goal, thus:

Advanced software technology that allows:

- optimizing processes by reducing time with the analysis of input and output data and by improving data processing (based on the data entered, conclusions can be drawn, decisions can be made, the state of the organization at a given time can be observed in the form of an analysis)
- continuous data collection and monitoring
- cloud computing for centralizing and storing data in real time, in a secure platform
- analyzing the data taken using graphs, based on classic quality assessment methods
- ensuring security, transparency and traceability of information using the Appsheet platform used, which offers these functionalities

Collaborative and intelligent system that allows:

- real-time monitoring and evaluation of processes, as well as proposing appropriate measures to improve them
- collaboration between humans and technology through the suggestions offered, for effective decision-making by those involved

Digitalization and automation of quality processes through:

- implementation of digital tools in quality management (digital audit, automated reporting)
- predictive analytics system

Sustainability and social responsibility:

- In the second phase of implementation, the aim is to use the collected data to reduce emissions and carbon footprint, according to the studies carried out
- Promoting transparency and accountability of the organization's staff
- Classification of the organization according to the size of CO_{2e} emissions

After implementing these recommendations and considering the 8 principles of the new Quality 4.0 theory (according to the Chartered Quality Institute), an easy implementation framework was created, a method that helps the organization evolve towards a digital organization, monitor its processes and at the same time improve its performance.

This method of transforming an organization into a Smart organization was completed with the creation of an application for small or medium-sized organizations in the private sector, which have an implemented or in the process of implementing a quality management system, in order to optimize processes, determine risks and opportunities and improve the activity.

The main goal was ease of revisions, easy to access/store/create documents, ease of use, notifications, time saving, process improvement.

The advantages obtained were reduced costs with quality, increased accessibility (mobile or PC), greater staff involvement, reduced cost compared to existing systems on the market, and increased productivity. At the same time, organizations that will evaluate their system in this way will find it much easier to analyze themselves according to the criteria of excellence.

However, there were constraints that arose in relation to the time used, the lack of popularity of the method, the limited resources allocated.

In achieving the main objective of the doctoral research and development activity, this doctoral thesis makes a series of contributions, the most important of which are as follows:

- identifying the existing associations in the specialized literature, between new technologies in Industry and new, Smart organizations, through the study carried out in chapter 5, which demonstrates the hypothesis that the market, the business environment evolves with technology, therefore, the proposal of methods in the field of new technologies, will result in the improvement of organizations.
- terminology related to new technologies can be proposed in defining new organizations, namely "Smart organizations" and at the same time constitutes a tool in itself for improving their processes (chapter 3)
- the studies conducted on organizations in Chapter 5 and Chapter 6 identified a method by which they can rethink their processes in order to improve them, the change being made with the help of practices that are accessible and within reach, both for employees and management. Change is welcome in the context of dynamic market evolution and fierce competition in the market.
- developing a model for improving the processes of a traditional organization chapter 7
- the sustainable approach of the proposed model, in accordance with the requirements of the EU common market, chapter 6

The results obtained led to the implementation of a method for improving processes in organizations and ensuring their transition to digital organization status, as well as the implementation of sustainability elements in order to reduce their carbon footprint.

8.2 Contributions

This thesis has achieved the set objectives and has thus made theoretical, methodological, and conceptual contributions. Knowledge from the fields of quality engineering, IT, statistics, and sustainable development has been integrated.

Theoretical contributions

The scientific importance of this doctoral thesis is supported by the contributions made to the development of a tool that uses classical methods of analysis and improvement of processes and

proposes their innovation using new methods and techniques, so that the transfer to a modern organization is made as efficiently as possible, within a reasonable time horizon.
The theoretical contribution consists in making a clear distinction between the classical approach to quality and the new one, thus bringing technological progress to the forefront, opening up new opportunities for organizations to adopt Smart transformation, differences highlighted in Table 8.1.

Table 8.1 Perspectives on approaching the notion of quality

Criterion	**Traditional quality management**	**Quality 4.0**
Focus	Manual process control	Integrating digital technologies for continuous monitoring and optimization
The role of people	Manual monitoring, periodic inspection	Collaboration and close interaction between humans and technology
Main tools	Diagrams, checklists, traditional audits	IoT Sensors, AI, Machine Learning, Cloud Computing, Blockchain
Nature of processes	Predominantly manuals and instructions dependent on the human factor	Automated, continuous, predictive and proactive

From the analysis of the research context in chapter 1 and the current state of the art regarding the classical quality improvement tools in chapter 2, with the help of the new trends and methods highlighted in chapter 3 in the field, the research in chapter 4 was carried out to identify the attributes necessary to transform a traditional organization into a Smart organization. The research in chapter 5 was then carried out, and the results obtained together with the research in chapter 6 constituted the necessary elements to lay the foundations for the method in chapter 7, namely the creation of the Quality 4.0 application. This contribution consisted in highlighting the new attributes characteristic of Smart organizations, which incorporate Smart technologies.
Another theoretical contribution was the identification of the relationship that exists between a Smart organization, profit and/or innovation. Smart organizations create the right conditions to stimulate innovation, which in turn creates profitability by increasing efficiency and gaining an advantage over the competition, and reinvested profits improve smart capabilities and innovation, because organizations can invest more funds in research, which leads to innovation. [Fig 8.1]

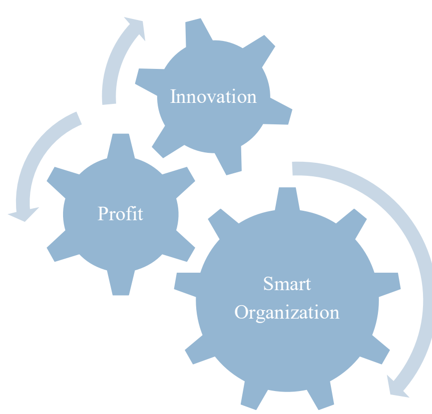


Fig. 8.1 The link between Smart organization, Profit and Innovation

Methodological contributions

The research focused on implementing a methodology that would ensure sustainability of the innovation framework previously obtained.
The method proposed in chapter 7 and materialized by obtaining an implementation tool, is structured on 3 levels:

- identifying and measuring indicators that need to be improved;
- combining improvement measures in the field of new technologies and Quality 4.0;
- the possibility of analyzing the state of the organization at any time.

Experimental contributions

The Quality 4.0 application was developed in Appsheet, hosted in Google Cloud. It can be installed on a mobile phone but is also accessible from a browser.

It is accessible to authorized personnel within an organization, who can make appropriate decisions. Within the organization, it can be accessed at any time by all personnel, based on limited rights, to observe the status of the organization at a given time, for informational purposes.

Read and write permissions are set for each user, so all staff have access to the application for viewing, but only delegated staff have access to both changes and reading.

The development of the application is based on the structure in Annex 1 which contains data relating to:

- Delimitation of processes and their main measurement indicators
- Collecting data related to indicators
- Assigning scores to processes based on importance
- Target values for indicators
- Proposals for improvement measures after those stated in the previous chapters
- Measurements, scores and values obtained after applying improvement measures

Data collection

The development of the application was based on data collected from the organizations in which the previous studies were conducted..

Benefits of implementing Quality 4.0

Following the implementation of the Quality 4.0 application, the following benefits were obtained:

- Continuous and real-time monitoring (monitoring of processes, thus ensuring rapid identification of indicators that need to be improved, as well as targets met)
- Increased predictability: allows the prevention of critical problems related to monitored indicators, thus reducing the costs associated with them
- Improving experience and increasing awareness among employees of the important role they play in carrying out daily tasks
- Reducing operational costs: optimizing processes leads to reducing costs associated with poor quality as well as increasing efficiency

Limitations and future directions

There are also a series of limitations, such as the fact that the analysis carried out regarding the phrase Smart Organization only considered the terms obtained related to this phrase, not taking into account other directly associated expressions, for example: Quality 4.0.

Another limitation is that the studies conducted within organizations were conducted over a limited period of time, namely 1-3 months, and the mirror, respectively the results after improvement, reflect the stage they were in at that time.

Another limitation identified is related to the sustainability part, in which emissions related to Goal 3, namely indirect emissions, were not considered, as they were not available.
It is also necessary to consider critical aspects, especially the longer time spent entering data into the system, the blockages that occur when the internet does not work, as well as the fact that the failure of the latter and/or the current makes it difficult or impossible to use the application.

Future directions

The practical importance of this doctoral thesis lies in the fact that the studies carried out represent a useful support system for those interested, while at the same time offering further directions for development and integration such as the integration of several standards (as the environmental one) or integration with other software applications.

A potential research direction for the future is to identify a methodology for establishing the level of digital transformation of an organization, namely whether or not an organization's digital capabilities are implemented and the degree of implementation, respectively a digital maturity model.

Another direction is to study the extent to which A.I. (artificial intelligence) can be integrated to provide completion suggestions within the application developed based on the model.

The application can be supplemented by including feedback from Quality 4.0 application users, thus providing a valuable resource to the organization for evaluation, measurement and control.

Strengthening sustainability aspects, namely the inclusion of ESG indicators: Environmental (environmental indicators - recycling rate, Social - social indicators - employee satisfaction, health and safety and Governance - corporate governance indicators) in the evaluation of organizations for a more complete evaluation, including more detailed analyses of the impact of activities on the environment, can be a potential complement to an evaluation tool.

* * *

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Anex A

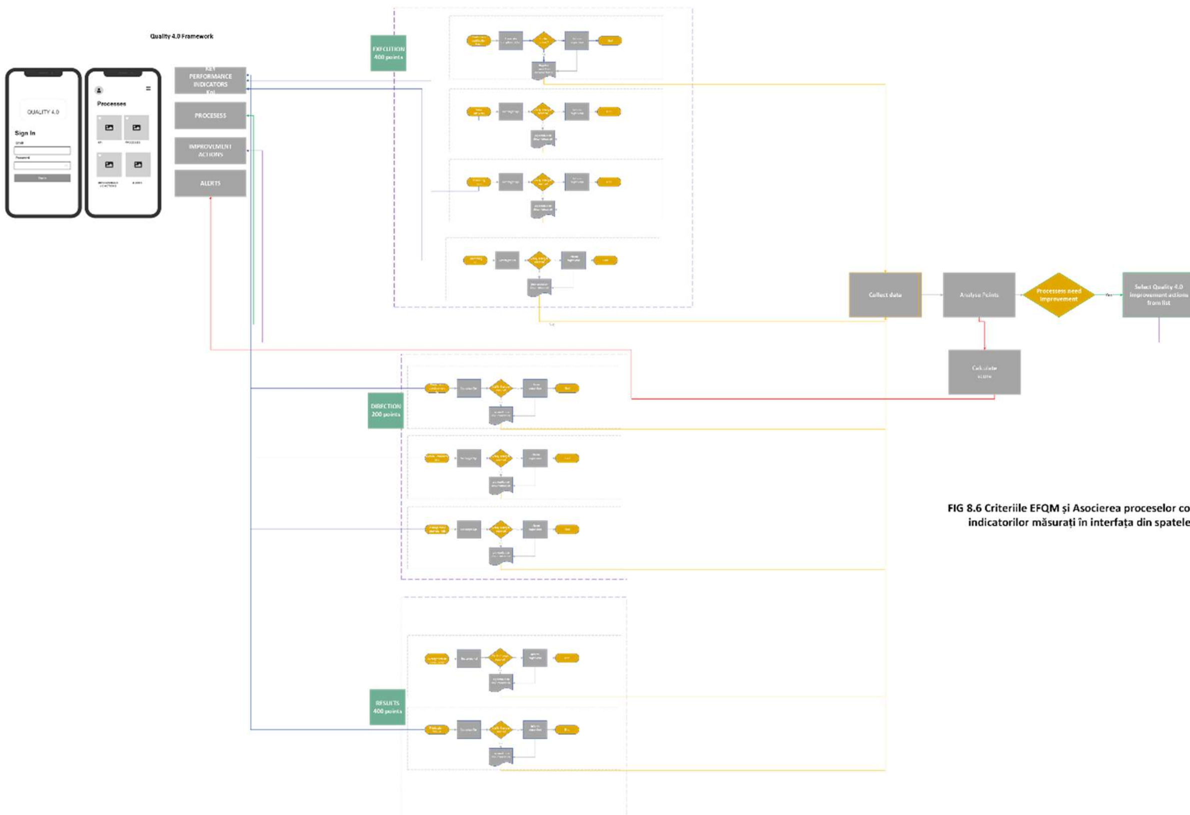

FIG 8.6 Criteriile EFQM și Asocierea proceselor corespunzătoare indicatorilor măsurați în interfața din spatele aplicației